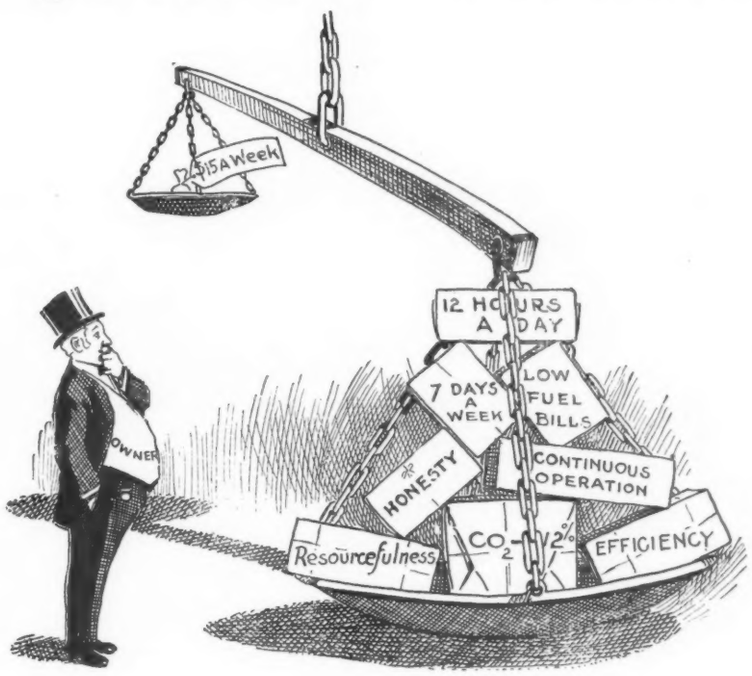
POWER

Vol. 38 NEW YORK, NOVEMBER 4, 1913 No. 19

A Question of Balance



MR. POWER PLANT OWNER—REFLECT A MOMENT!

Is the scale in your plant evenly balanced? That is, in proportion to what your engineer puts on his side of the scale, are you correspondingly loading the other pan?

□ □ □ □

If not, your engineer cannot be satisfied, at least not for long. If he is not satisfied, then ten chances to one, he is on the lookout for another job and his successor may cause the beam to tip the other way by not having so many nor so heavy packages to put into the pan on his end.

A man who is paid according to the number, size and quality of the packages he delivers will stick to his job.

First get the right man and for every additional weight put on his end of the beam, add sufficient remuneration to balance the scale evenly. You will find it excellent economy.

[*Written by Everard Brown, Pittsburgh, Penn.*]

The 25,000-Kw. Turbine for Fisk Street

SYNOPSIS—Detailed information regarding this unit has been eagerly looked for ever since the announcement of the placing of the order. Its great capacity, low steam rates, and the fact that is of foreign make combine to make it an object of engineering curiosity and interest.

The 25,000-kw. turbine which we announced some time ago had been ordered from C. A. Parsons Co., Ltd., by the Commonwealth Edison Co., of Chicago, is being erected in the Fisk St. station of that company and should be ready for operation early in the winter. This unit marks not only the limit in capacity for which a single generator has yet been built but also the lowest guarantee which has yet been offered for steam rates, unless the guarantee has been beaten by that of the 30,000-kw. unit now being built by the General Electric Co. for the Northwest station of the Commonwealth company.

The figures for the Parsons turbine are:

At 10,000-kw.	12.50 lb. per kw.
15,000-kw.	11.65 lb. per kw.
20,000-kw.	11.25 lb. per kw.
25,000-kw.	11.65 lb. per kw.

These figures include the energy necessary for excitation purposes, but do not include the energy necessary for ventilating the generator, nor for the condenser or other auxiliaries.

The steam conditions upon which this guarantee is based are 200-lb. gage pressure, 200 deg. F. superheat at the throttle, and an absolute back pressure equivalent to 1 in. of mercury.

The Rankine efficiency, or ratio of work produced to that which would be produced by a 100 per cent. engine working upon the Rankine cycle between the given limits of pressure and temperature, is 72.4. It is said that a penalty of £500 ($2500) is incurred for each one-fifth of a pound in excess of 11.25 at 20,000 kw., and that an equal bonus will be paid for any improvement in that rate.

A longitudinal section of the unit is given on the plate herewith, and reproduction of photographs taken at the Heaton works of the Parsons company, at Newcastle-upon-Tyne, England, where it was built, are reproduced on pages 631 and 633. The turbine is in two sections, a single-flow, high-pressure section with six stages or groups of blades, and a double-flow, low-pressure section, also with six groups of blading upon each side of the entry.

The High-Pressure Turbine

Steam enters the high-pressure belt *A* from below, through the opening *B*. The secondary, or overload steam belt, is shown at *C*, high-pressure steam being automatically admitted thereto through the opening *D* when the load rises sensibly above 20,000 kw. The entry blading is 2¾ in. in height and must pass 225,000 lb. of steam per hour, 62.5 lb. per second, at the guaranteed steam rate and normal load. The final blading for the high-pressure section is 6½ in. in height. The diameter of the entry-blade circle is about 52 in., and of the final blade circle about 72 in., giving mean blade speeds of about 170 and 235 ft. per sec. respectively at the rated speed of the turbine, 750 r.p.m. Those of the blades which are subjected to the action of superheated steam are of copper; the remainder of brass. All are heavier at the base than at the tip, and are lashed by silver-soldered binding strips. Three dummy pistons *E, F, G* are used to balance the end thrust, equalizing pipes *H* and *I*, connecting the chambers *hh'* and *ii'*, while the pipe *J* transmits the outlet pressure in the chamber *j* to the space *j'* back of the largest dummy.

The casing is four-parted with one horizontal division in the plane of the axis and a vertical division between the fourth and fifth rows of blading. The high-pressure end is of cast steel, the remainder of cast iron.

The two smaller dummies *E* and *F* and the high-pressure end of the main shaft *K* are integral with the drum and of forged steel, specified to have an ultimate tensile strength of 35 to 40 tons per square inch, and an elongation of 20 per cent. At the exhaust end the drum is shrunk on and bolted to the enlarged end of a separate length of shaft *L* of the same material.

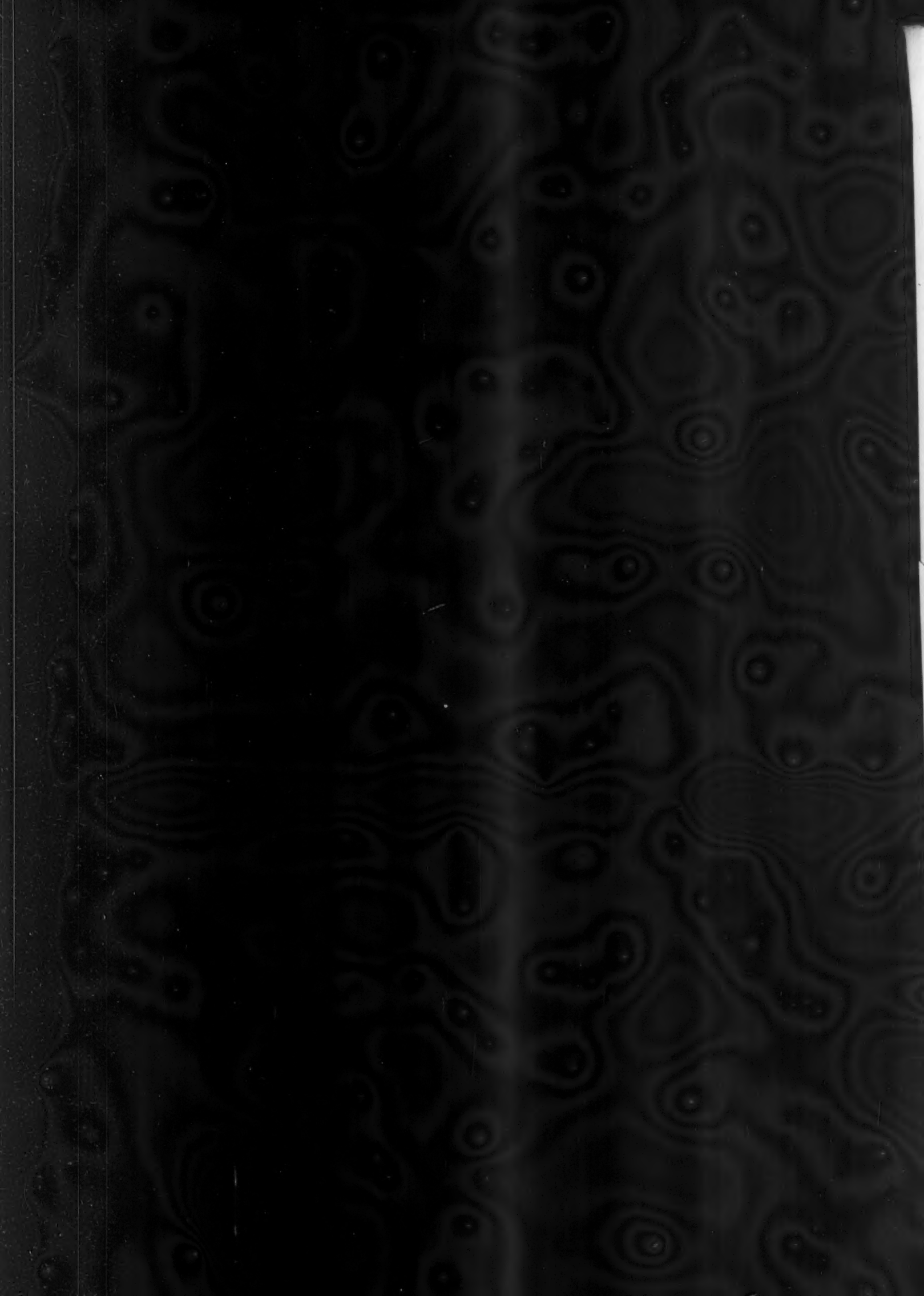
There are in the six groups of high-pressure blading 64 rows of moving blades, and steam in passing through them is expanded to a pressure of about 25 lb. absolute under normal conditions, which would make this section develop quite some less than one-half the total load.

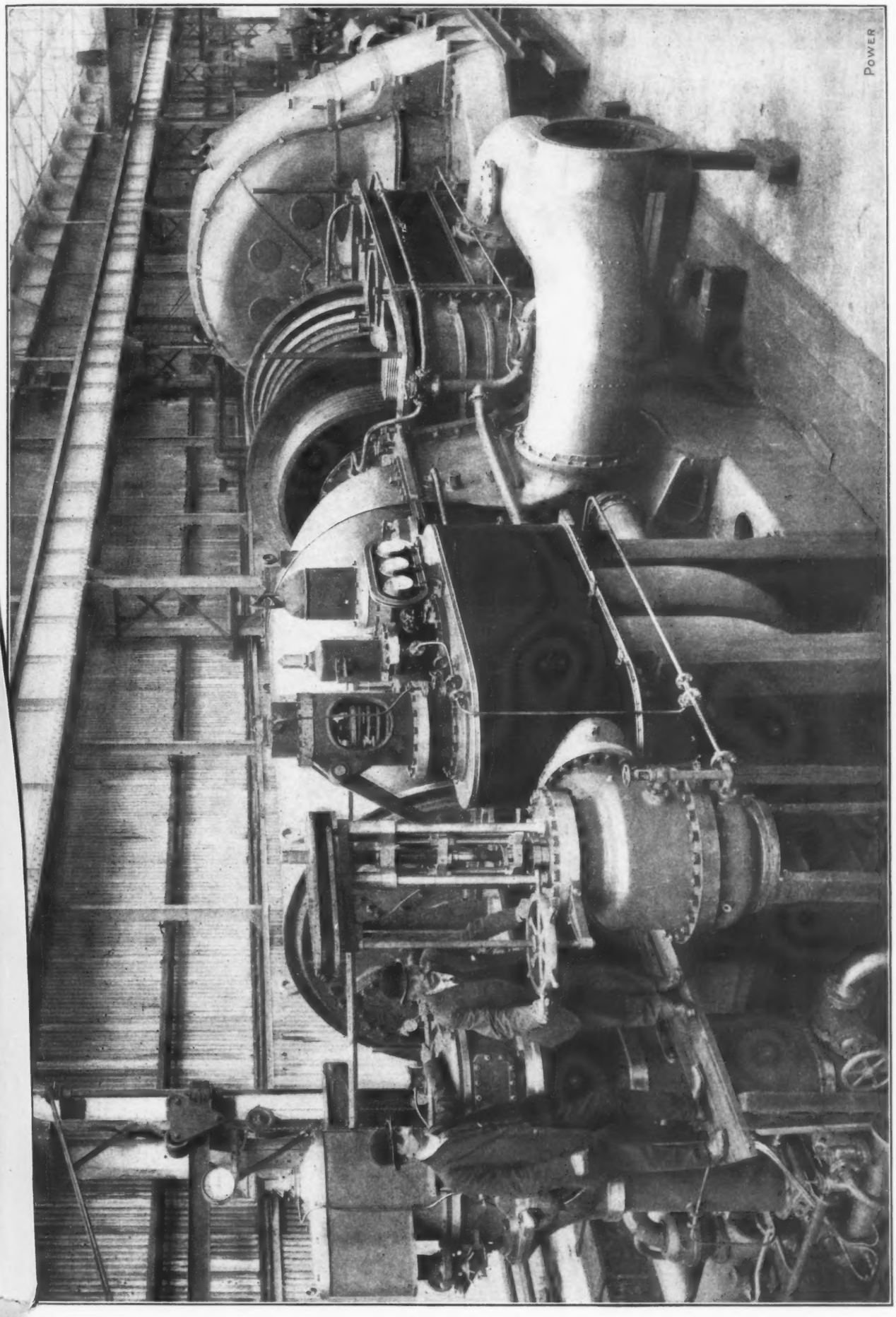
The Low-Pressure Turbine

From the exhaust belt *M* of the high-pressure section steam passes by two 30-in. pipes to the central steam belt *N* of the low-pressure section, where it divides, passing through the blading in both directions to the exhaust chambers *PP*. The blading ranges from 2¾ in. at the entry to 19 in. at the discharge. The mean diameters of the blade circles are about 87 and 103 in., giving average blade velocities of 285 and 337 ft. per sec. The low-pressure section has 24 rows of moving blades on each side of the center. The drum is of uniform diameter and is attached to the shaft through connections which allow their relative position to vary under differences of temperature without affecting the register of the blading. The central spider *Q* stiffens and supports the drum at the point where the radial clearance on account of the shortness of the blades must be kept at a minimum, and stability and maintained precision are of particular importance. The casing of the low-pressure section is of cast iron throughout and weighs about 150 tons. The bottom portion is built in four, the top in two sections, as the drawing indicates. The standard Parsons low-pressure gland is used on both ends, sealed with steam exhausted from the governor relay. The final blades discharge the steam practically into the condenser itself.

The Condenser

The condenser shell, which is suspended from the bottom of the turbine so that it forms practically a continuation of the turbine case, is built of steel plate externally stiffened by bulb irons or deck beams so as to present no unnecessary obstruction to the movement of the steam within. The tube-supporting plates and water ends are of cast iron; the tube plates and tubes of brass. The tubes are 1 in. in diameter, 16 B.w.g. and 15 ft.





THE LARGEST TURBINE AND GENERATOR YET BUILT. VIEW FROM HIGH-PRESSURE END

long, arranged in two groups for two water passes. The entrance orifice is 69x26 in., and the discharge pipe 48 in. in diameter. The rectangular opening where the condenser shell joins the turbine case is 12x21 ft., giving a section of 252 sq.ft. Allowing that 20 per cent. of the steam is condensed by the conversion of its heat into work, this passage will have to pass at normal load 2,136,000 cu.ft. per min., which means an average velocity of nearly 8500 ft. The greater part of the weight of the condenser and its contents is carried upon springs, of which there are eight, placed upon beams set into the concrete foundation, as shown at *RR*. The condenser contains 39,300 sq.ft. of tube surface, being 1.965 sq.ft. per kw. at the normal, and 1.57 sq.ft. at the maximum rating. In addition to the main condenser, a feed-water

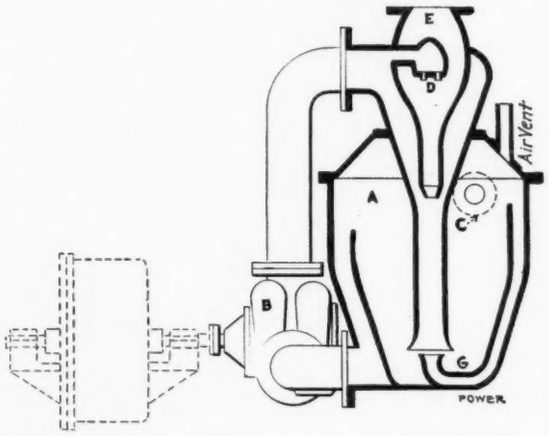


FIG. 1. KINEMATIC EJECTOR

heater section is to be built in the steam entrance into the condenser and to contain 470 sq.ft. of surface.

The equipment of pumps to be used for condenser auxiliaries and for other purposes in connection with this unit, is being furnished by Henry R. Worthington, and consists of:

One horizontal tri-rotor, volute, motor-driven centrifugal pump for circulating water, having a capacity of 42,000 (U. S.) gal. per min.

One horizontal, two-stage, motor-driven, centrifugal hotwell pump, having a capacity of 750 gal. per min.

One horizontal, centrifugal, motor-driven pump, for use with the kinetic injector, having a capacity of 4000 gal. per min.

Two horizontal, centrifugal, motor-driven, surface pumps, having a capacity of 300 gal. per min. each.

One turbine-driven and one motor-driven type centrifugal boiler-feed pump, having a capacity of 750 gal. per min. each.

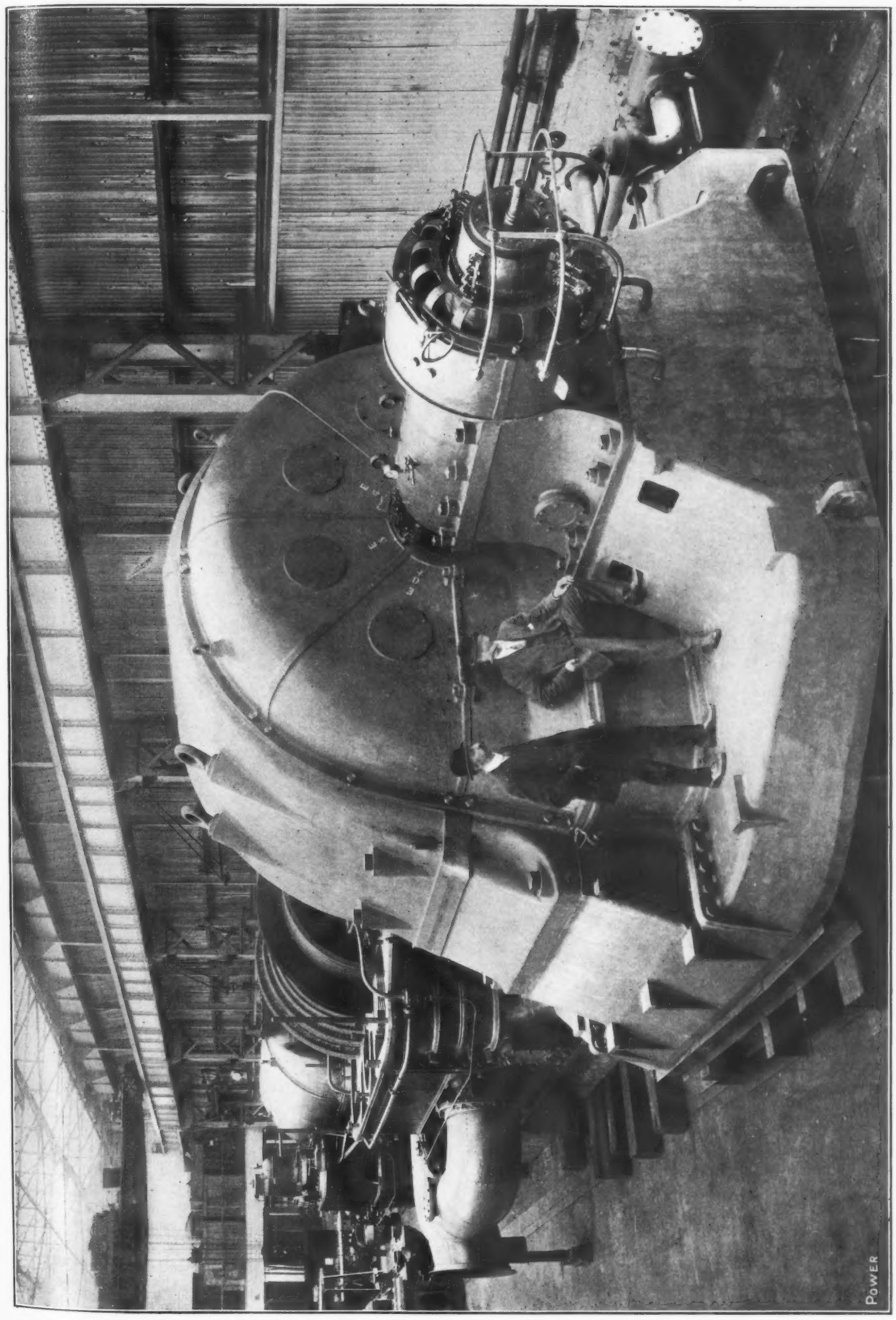
The motor-driven auxiliaries are equipped with squirrel-cage induction motors.

In place of the usual air pump, a kinetic ejector, furnished by Richardsons Westgarth & Co., of West Hartlepool, England, is used. This ejector is shown diagrammatically in Fig. 1. The discharge from the hotwell pump flows through the chamber *A*, discharging therefrom through the flanged outlet *C*. An ordinary centrifugal pump *B* draws a portion of this condensate from the tank *A* and returns it to the spray nozzles *D*. The air from the condenser is pushed into the chamber *E* by a steam jet, as will be seen upon the large plate, where the ejector is shown in a somewhat different form from this diagrammatic presentation. The air and condensable vapors are carried along by the water jets which issue under pressure of some 40 lb.; the vapor is largely condensed and the air caught in the air pipe *G* is carried above the water level and discharged through the vent, avoiding the aërating of the feed water, while the heat from the steam jets and the condensed vapor is returned to the boiler with the condensate.

In the ejector, as actually applied to the turbine, and shown in the large plate, the kinetic tank consists of three sections; the middle section constitutes the kinetic tank proper, which has just been described, in addition to which there is a tank on one side which performs the function of the feed-water heater, and on the other side is a hotwell from which the feed pumps take their suction. The latter is provided with a float connected to the makeup water supply, which maintains an adequate supply for the feed pumps. The kinetic tank proper has an outside chamber into which the water overflows from the central chamber, in which the nozzles are arranged in annular form, passing through a number of copper strainers, the water flows from this section to the feed-water heater, where it is heated by a number of steam jets which are supplied with steam from the connection between the high- and low-pressure cylinders on the turbine, or from the steam-driven boiler-feed pump. The feeder section is connected with the hotwell by a passage running through the bottom part of the kinetic tank.

Should the supply of water in the hotwell tank be more, temporarily, than the demand of the boiler-feed pumps, the excess will pass out through the overflow pipe, which runs into a large reservoir, located below the level of the basement floor. The use of this reservoir serves to save the pure water of condensation, which would otherwise be wasted. When the supply in the hotwell becomes deficient, a float valve serves to establish a connection from the reservoir into the condenser, thus furnishing the necessary makeup water. An additional float valve in the large reservoir serves to maintain the level at a predetermined height and admits water from the filtered-water system in the station. The two turbine sections are connected through a rigidly bolted coupling *S*. Between the low-pressure turbine and the generator is a flexible claw coupling *T*, which is fitted with a worm pinion through which the turbines may be turned by an electric motor when they are open for inspection. The longitudinal expansion is provided for by allowing the foot of the turbine at the high-pressure end to rest freely on the pedestal between slipper side guides. Each turbine and the generator stands between its own pair of bearings, making six bearings in all. The overall length is 76 ft. 2 in. The greatest width is 19 ft. The height from the base of the condenser to the highest part of the turbine is 30 ft., of which only 10 ft. is above the floor level.

The steam-admission valves, the steam-governor valves, the emergency and bypass valves, and the chests containing them, are steel castings which have been used wherever the part came in contact with superheated steam, and, like the cast-steel portion of the turbine casing, were annealed before and after rough machining. This portion of the turbine is of the standard Parsons design, with separate emergency and regulating governors, the latter being controllable from the switchboard. It is specified that the regulating governor shall not allow the



25,000-Kw. Parsons Turbine for the Fisk Street Station, Chicago. View from Generator End

load to vary more than 3 per cent. between no load, and 25,000 kw., with a momentary variation of not more than 5 per cent. In addition to the two governors mentioned, a safety governor is attached to the end of the high-pressure turbine shaft independent of the main governors, and capable of being tripped by hand from the engine-floor level. A steam resetting gear is provided for this valve.

We are indebted for permission to acquaint our readers with the details of this remarkable machine to Samuel Insull, president of the Commonwealth company, and for access to the drawings and information to Sargent & Lundy, of Chicago, consulting engineers to the company.

Improved Pen for Chart-Recording Instruments

The chart records from recording water or steam meters and pressure gages, which are usually placed on permanent file, form an increasingly important part of the daily history of the plant's performance. Often, however, the line drawn is very broad and sometimes blotched or spotted, making the diagram unsightly and difficult to read, or to integrate accurately, especially if the curve is somewhat irregular; sometimes, soon after the pen has been filled, the chart acts as a blotter soaking up the entire filling in one huge blot. These faults may be traced

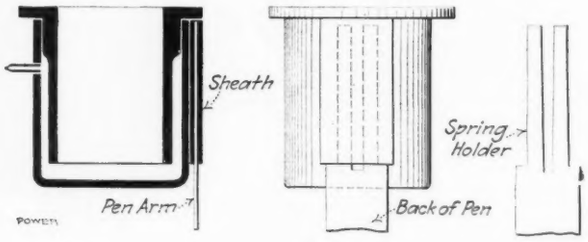


FIG. 1 FIG. 2 FIG. 3

DETAILS OF PEN

to the use of poor quality ink, or of improper consistency, but more frequently to defects in the pen which traces the line.

The pen shown in cross-section in Fig. 1 was designed to avoid pen troubles. The general shape is that of a cylinder, about $\frac{3}{8}$ in. in diameter and of the same height. This pen depends for its action on two principles: Capillary attraction and the inverted siphon. It is made in two parts, both of bronze; the outer shell and the inner partition to which the cap or cover of the pen is joined. The inner dividing wall descends to within $\frac{3}{64}$ in. of the bottom of the ink reservoir. Two concentric chambers are thereby formed, the inner being open and the outer covered by the cap. The edge of the latter is knurled so that it may be easily grasped with the fingers when it is desired to take out the inner shell for the purpose of starting or cleaning the pen.

A short piece of bronze tubing, not over $\frac{3}{32}$ in. in length, nicely smoothed and rounded at the end, forms the pen point proper. The short length is found to be of advantage; long tubes clog easily and after their interior is caked with ink, cleaning is next to impossible.

The method of fastening the pen to its holder is illustrated by Figs. 2 and 3. The end of the pen arm terminates in a spring fork which is inserted in a sheath at the back of the pen. This method of fastening holds the pen rigidly and, since no solder is used to make the joint, the pen may be easily removed from the arm whenever desired.

When starting, the cover of the pen is removed and the reservoir filled with ink to about three-quarters of its depth (it is not necessary to have the inlet of the tube submerged when starting). The cap is then replaced and brought home by a slight pressure on the top, keeping the opening covered by the thumb. The slight air pressure thus brought into action on the surface of the ink in the reservoir is sufficient to force a small amount through the tube which forms the pen point.

Fig. 4 shows a chart made by the first pen used on a Venturi meter type M register-indicator-recorder, measuring boiler feed water. Seven charts can be made from a single filling of the pen.

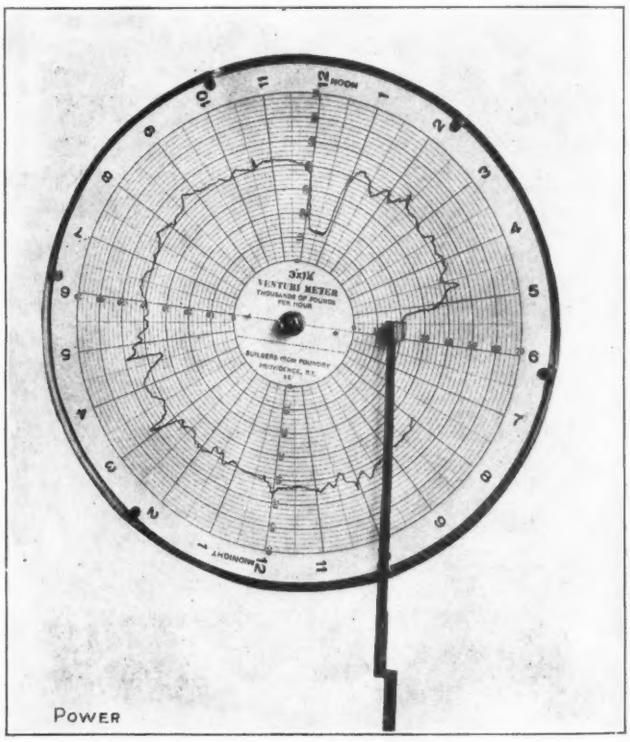


FIG. 4. CHART MADE WITH NEW PEN

The level of ink in the pen is always visible without removing the cap. It has been found by test that the tubular point of the pen will draw the ink from the outer reservoir until the level drops below the middle shell when the siphon "breaks." If the pen is refilled before the "breaking point" is reached, the feeding is continued without pause and it is unecessary to remove the cap to start the pen. The short tube is easily cleaned by piercing it with a fine wire.

The pen, which is made by the Builders Iron Foundry, Providence, R. I., will soon be furnished with all of their Venturi meter-recording instruments. The pens may be procured, however, for use with almost any type of recording instrument and are easily applied. Both pen and pen arm are finished in heavy nickel-plating.

Boiler Attachments—IV

By J. E. Terman

SYNOPSIS—Fusible plugs are shown to be a disadvantage unless properly placed and cared for. Something is said regarding hand stop valves, also automatic back-pressure valves, their position in the pipe line and how a combination of both is advisable.

A fusible plug, like any other automatic device, requires a little intelligent attention at stated intervals, in order that it may be of service when required. The filling of a fusible plug should be removed at least once every year and pure tin should only be used for refilling. A fusible plug should be examined once a month, and both the surfaces exposed to the gases and to the water should be scraped clean. On many types of boilers a fusible plug is of doubtful utility, and on some its use is detrimental. For example, on the vertical tubular type of boiler the fusible plug is necessarily placed in one of the tubes, and it is very difficult to make the joint between the tube and plug tight. The plug after being screwed in place usually projects into the tube such a distance that it is impossible to pass a brush or scraper through it, consequently, the tube gradually fills up with soot and scale until it is completely stopped. If no gas from the furnace passes through the tube, of course, the fusible plug is useless and the only result is the loss of the use of the tube for generating steam.

The usual location for a fusible plug in a horizontal, return-tubular boiler is in the rear head about two to two and a half inches above the tops of the top tubes, and this is about the only place that it can be successfully applied. One of the troubles connected with the use of fusible plugs, is, that when a plug burns out it requires the closing down of the boiler to renew it; after one or two experiences of this kind, it seems hard for the average boiler attendant to resist the temptation to replace it with a solid plug. On the locomotive-type boiler, the fusible plug should be placed in the crown sheet and project about an inch above the top of the sheet. The fusible plug is probably more efficient as a low-water alarm on the locomotive-type boiler than on any other. For water-tube boilers, the fusible plug should be placed at the lowest safe water line and at the nearest point to the furnace in the direct path of the gases from the fuel bed. The fusible plug may be considered an antiquated type of low-water alarm and its functions are much better and more economically performed by more modern appliances, which can be tested to ascertain if they are in working order or not, without actually having low water in the boiler.

Stop Valves

The stop valve is an important part of the boiler equipment and not only must it be of good construction, but it must be properly located, if it is to give satisfactory service. In general, a stop valve should be located as near the boiler as possible, so that the steam may be cut off should any defect occur in the piping. Another feature that sometimes makes it desirable to locate the stop valve near the boiler, is that, when long connecting pipes are used between the boilers and a steam header serving a number of boilers, if the stop valves are not located near the boilers, severe strains may be produced in the piping due to the contraction of the pipes connected to idle boilers, should the stop valves be located near the header.

Another requirement, the most important of all, in regard to the location of the stop valve, is that it should be so placed that no water of condensation can stand in the pipe when the valve is closed. Failure to observe this necessary precaution for safety has often resulted in the loss of life or the serious injury of those in charge, due to the breaking of fittings or pipes from water-hammer action; such accidents have also at times led to the explosion of the boiler itself. Fig. 21 illustrates a bad arrangement in this respect, that is frequently met with in practice. The dotted lines show two positions for the header that would remedy the defect. If the conditions are such that the stop valve can not possibly

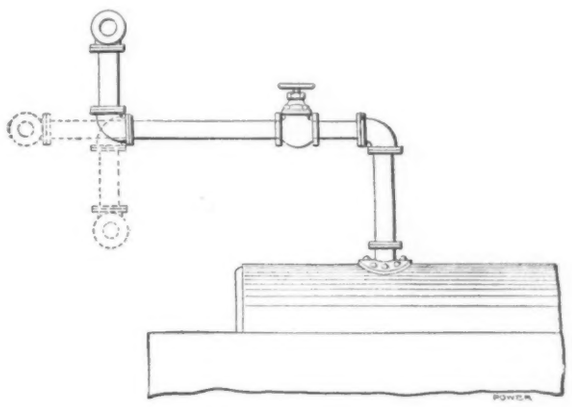


Fig. 21. Improper Steam-Pipe Connection

be located so that the condensed steam will drain back into the pipe line, then a bleeder of ample size should be provided and located so that it will drain the pocket. The boiler attendant should regard it as his most important duty to see that the piping is thoroughly drained before attempting to cut a boiler in on the line.

There is another feature that should influence the location of the main stop valve, if the first two mentioned do not absolutely fix its position, and that is accessibility for operation. The normal purpose of this valve is to cut the boiler from the line to shut it down or re-connecting it after a shutdown. Under such conditions the operator can usually go to the top of the boiler to perform this duty at leisure. However, when an accident occurs and it is required to cut a defective boiler out, to prevent the other boilers from emptying their steam through the defective one, the matter is different. Under such conditions, if a hand-operated valve is used, it is generally impossible to reach it if placed in the usual location. The best method of overcoming this difficulty is to put a chain-sprocket wheel on the valve stem in place of the regular handwheel and lead a chain from this wheel over suitable pulleys to a point where it can be readily reached from the boiler-room floor level.

The automatic stop valve is, of course, the best kind of equipment for the purpose we are discussing, for it stands ready at all times, if in working order, to shut off a boiler when the pressure on the boiler side drops below the line pressure. While the automatic stop valve performs this important function, it also performs another of equal if not greater importance, and that is, it automatically prevents connecting a boiler to the steam line until the pressures on the two sides are equalized, if the valve has been made operative before an excess pressure has been built up in the boiler.

To really protect a boiler operated with others, and the attendants who may be required to work inside when shut down, the stop-valve equipment should consist of two valves, one an automatic placed nearest the boiler and the other an ordinary stop valve. This arrangement allows the pressure to be removed from the automatic valve at any time without shutting down the entire battery of boilers, and if a bleeder valve of ample size is located on the main pipe between the two valves, steam and hot water may be kept from entering the boiler, even if both valves are not perfectly tight. The reduced effort to clean a boiler and the better cleaning done when interference by steam and hot water is eliminated will often pay for an extra valve in a short time, to say nothing of the better facilities offered for inspections.

The question of which way the stop valve should be turned in connecting it, if of the globe-valve type, is often raised, and it can be discussed, pro and con, in many ways. If the plant consists of more than one boiler, the importance of being able to pack the stem without taking the pressure from the steam line would seem to require that the top side of the valve be connected toward the boiler. If dependence is to be placed on a single globe-stop valve, there is possibly less liability of the breaking of the parts and admitting steam to an idle boiler by reversing the position; so, with a single valve used, it is safest to turn it so that the line pressure will be on top of the disk when closed, and safety is of paramount importance.

Another precaution for safety that should be taken to protect those who may be required to work inside idle boilers, and this applies especially to large plants, is to provide chains and locks, for locking shut the stop valves as well as other valves that control connections that may admit hot water or steam to an idle boiler. The keys to such locks should be kept by the chief engineer or other attendant in responsible charge. It would seem that the recital of some of the details of the frightful accidents that have occurred with considerable frequency on the account of neglecting such precautions, would be sufficient to secure from the management any reasonable sum for the necessary equipment.

Dampers and Damper Regulators

The damper is a more important portion of the boiler equipment than is usually credited. When horses are hitched together, the draft gear is usually arranged so that it will be necessary that all pull alike, but the average steam engineer will hitch from two to ten or more boilers together without apparently giving the matter much thought as to whether each will carry its proper share of the load or not. The main function of the individual boiler damper is to aid the operator to distribute the total load between the boilers according to the capacity of each one. The correct distribution of the load on plant efficiency is of importance.

It is well known that the economy, as regards fuel consumption, is much less with a boiler carrying a small load than if it were operated at rating or slightly above, and that a loss of efficiency is also experienced if an excessive load is carried. Therefore, when two or more boilers are operated on a load that approximates their combined capacities, the efficiency will be maximum when the load is distributed between them in proportion to their capacities, and the efficiency will be less the greater the inequality in the distribution of the load. Under bad conditions of distribution the loss in fuel may amount to 10 or even 20 per cent. of the fuel consumed.

The individual damper in the uptake from each boiler can be used to distribute the load properly by producing the required draft conditions in the furnace under each boiler so that the proper amount of heat may be generated to suit the capacities of the different boilers. The best way to judge when the loads are properly equalized is to have a steam-flow meter attached to each boiler, so that the actual amount of steam delivered to the line may be seen, but if the management of the plant can not be induced to purchase such equipment the engineer should not be discouraged, for paying attention to the amount of coal burned under each boiler, will soon give a clue to the proper adjustment of the dampers for equalizing the load on the various boilers. If one boiler has twice as much heating surface as another has, it should care for twice the amount of heat, and the furnace should be capable of consuming twice the amount of fuel and delivering to the boiler twice the amount of heat. Sometimes it will be found that the grate area will require changing so that the load may be properly distributed.

After the positions in which the individual dampers must be placed to properly distribute the load have been determined, they should be marked and kept at these positions whenever the boiler is in operation, unless changed conditions in the plant make a readjustment necessary. All regulation of the draft that is required to care for changing load conditions, should be cared for by a main damper, placed in a portion of the main flue that carries the gases from all the boilers to the chimney. By this means the proper distribution of the load between the different boilers is maintained under changing load conditions. The damper regulator should always be arranged to operate the main damper.

Plants are frequently found where a regulator is attached to each individual boiler. This arrangement can never give the best results, regardless of the value of the regulator used, because it is impossible to adjust the different regulators to work in unison. There are many different makes of damper regulators on the market, but all work on about the same principle. A rising steam pressure actuates a valve which admits steam, air or water to a cylinder, and the movement of the piston in this cylinder closes the damper. The reversal of the operation is accomplished by weights or other means, when the boiler pressure has dropped below a given point.

A point about dampers that properly should be cared for by the boiler maker, but which the engineer should understand, is that they must not be made to fit tight

in the flue. A tight damper is liable to stick due to warping or expansion, and it is also liable to give trouble by causing gas explosions in the flue. There should always be sufficient draft on a boiler to prevent the formation of, or to remove, the gases that may be distilled from the bed of fuel when the draft is cut off; for unless this gas is carried off as fast as it is formed, serious explosions are liable to occur.

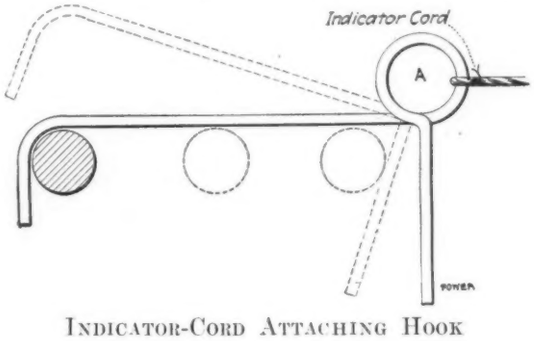
When firing a boiler, it is necessary to open the firing door wide, and this permits a rush of cold air to enter the furnace if the damper is open. To prevent this, the dampers are sometimes arranged so that they are automatically closed on each boiler as the furnace doors are opened. This is a good scheme, and it doubtless relieves the boiler of considerable strain due to sudden changes in furnace temperature. Since a damper regulator operates on differences of steam pressure only, without reference to furnace conditions, it should be set to operate at a pressure somewhat higher than the ordinary running pressure desired, in order that the fireman may regulate the pressure by his method of firing as far as possible. It is wasteful of fuel to have large quantities of green coal lying on the fuel bed with the draft checked, for under these conditions large quantities of the combustible portions of the coal escape up the stack unburned.

Handy Hook for Indicator Cord

By Paul A. Baumeister

The illustration shows a hook that is of material assistance in hooking up an indicator cord, while running at high speed. This device has lately come to the writer's attention and it may be new to others.

As shown, it consists of a special hook made from stiff wire. The hook is driven from a bar connected to the



Indicator-Cord Attaching Hook

crosshead. To hook up while running the loop *A* is held between the thumb and first finger of the right hand, the hook being held in the position shown by the dotted lines. The left hand is held loosely around the string to catch the hook should it fail to catch. The hook is now moved toward the bar on the crosshead until the bar strikes the end of the hook. This will swing the hook between the thumb and finger to a horizontal position, as indicated by the full lines. On the forward stroke the bar will catch the hook, pulling the latter out of the hand. The dotted lines under the hook show how the hook may rest on the pin and hook on.

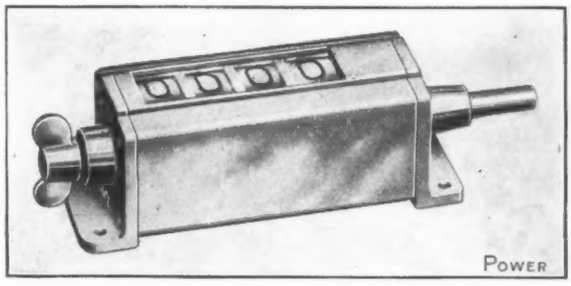
To disconnect the hook the hand is held loosely around the indicator cord and moved toward the hook until the arm of the hook strikes the fingers. This will tip up the hook and unlatch it.

Veeder Setback and Locked-Wheel Counters

The illustration shows one of the counters which have been brought out by the Veeder Manufacturing Co., Hartford, Conn.

The four-wheel setback counter is shown herewith. When desired the counter can be turned forward by one turn of the knob, shown at the left end of the counter, until all of the figures are at zero. The resetting shaft picks up the number of wheels from any position and carries them forward to zero.

The counter is built up of units, each unit consisting of a short section of shell, which carries a pinion and incloses the number wheel, with the exception of an opening through which the figures are read. The usual number of wheels supplied is four, but the counter may be



Veeder Setback Counter

made up with but two, or in special cases, with six or even eight sections. The counters are dust-proof and may be made waterproof by a suitable cement placed around the glass.

In the center of each number wheel is a small single-toothed ratchet wheel or cam, which engages with a single pawl, attached to the number wheel. The small cams are provided with a key which engages with a groove or keyway in ths resetting shaft.

The locked-wheel counter is similar to the setback counter, except that the transfer pinions are solid and the number wheels are not provided with cams and pawls for setting them to zero. The number wheels are locked in all positions and cannot be moved, except through the mechanism which is provided for driving the right-hand ring.

Both styles of counters are furnished with the same form of driving mechanism. A rotary ratchet drives the right-hand wheel forward by an oscillating motion of the lever on the driving shaft. The driving shaft may be rotated through any number of degrees, or even revolved continuously in either direction. If driven forward, it will count 10 for each revolution; if driven backward, the number wheel will not be moved. An oscillating movement of from 40 to 60 deg. will count one figure at each movement.

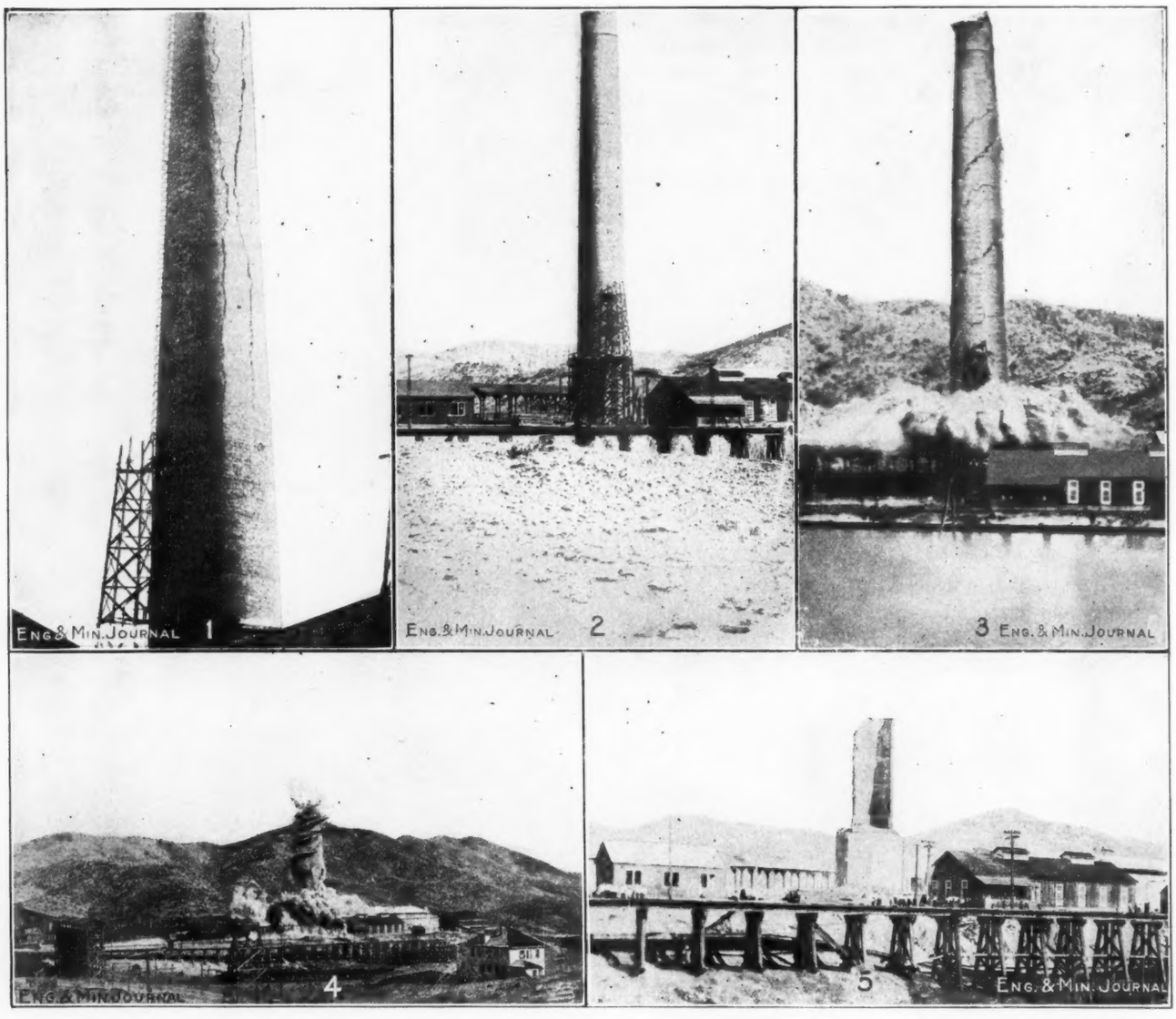
In the direct drive, the driving shaft is directly connected to the first or right-hand wheel and one revolution of the driving shaft will count 10. If the shaft is run backward, the number will be subtracted.

In the revolution counter, the right-hand wheel is driven by a gear, mounted on an eccentric on the driving shaft, but is prevented from turning by a short oscillating link. It counts one figure for every revolution of the shaft.

Wrecking the Balaklala Stack at Coram, Calif.

The tall, hollow-tile stack at the works of the Balaklala Consolidated Copper Co., at Coram, Calif., was recently wrecked by blasting out the lower part of the round portion of the stack, just above the octagonal base. The stack was 275 ft. high; the octagonal base about 40 ft. high. After the stack had been used 18 months, it began to crack and flatten on one side. Some people said it had been struck by lightning, but it is not positively known that this is true. The condition of the stack on the south side is shown in Fig. 1. Where the cracks are, the stack had bulged out, and on the left, where the iron ladder-rungs can be distinguished, the stack had flattened so that when one went inside and looked up, there was probably 10 or 12 ft. of the inside which, instead of being a circle, was practically straight across.

Many plans for saving the stack were discussed, such as banding, etc.; but as every few days a lot of brick would fall from the cornice, making it extremely dangerous, it was feared that, by working on the stack, some of the men might be injured. Fig. 2 is the photograph taken from the west side of the stack and shows how the top had crumbled away, several feet of it having fallen from time to time. In Fig. 3, the condition of the stack at the time of firing the blast, and just before it fell, is shown. In Fig. 4 the stack is shown a little later than in No. 3. Fig. 5 shows a piece remaining after the blast. This piece was taken down a few days later.



FAILURE AND WRECKING OF THE HOLLOW-TILE STACK OF THE BALAKLALA CONSOLIDATED COPPER CO.
In June a 135-ft. brick stack in Cleveland, Ohio, was struck by lightning, causing almost the same condition shown in Fig. 1.

In wrecking the stack, 72 holes were drilled around half of the base, and in each hole three sticks of 40 per cent. powder were placed, and all the holes were fired simultaneously by an electric battery. It is understood that the hollow tile of which this stack was built were imported from Germany. The cost of the original stack was $35,000. It is probable that the stack will be rebuilt to a height of 40 or 50 ft. above the 40-ft. base, using the same old material; possibly it may be built higher.—*The Engineering & Mining Journal.*

ELECTRICAL DEPARTMENT

Sixty-Cycle Rotary Converters*

By B. G. Lamme

One of the most significant developments in the past year has been the greatly increased use of large 60-cycle rotary converters by central stations. Shortly after the 25-cycle converter became prominent in electrical work, that is, 15 to 18 years ago, the problem of 60-cycle converters was also presented and such machines were built and installed in a number of places. Some of these were fairly successful, while others were failures. Apparently, in some of these cases of failure, the converter itself was not entirely to blame, as it was operated under conditions which would now be considered impracticable.

Peripheral Speeds

Relatively low speeds were considered necessary from the commercial standpoint, and with 60 cycles this meant a large number of poles. Also manufacturing limitations called for relatively low peripheral speeds of the commutators. In those days commutator speeds much in excess of 4000 ft. per min. were considered prohibitive, and unduly dangerous. The peripheral speed of the commutator equals the distance between adjacent neutral points multiplied by the alternations per minute. On this basis, 3600 ft. peripheral speed with 60 cycles per second gave 6 in. between adjacent neutral points. Even 4200 ft. peripheral speed gave only 7 in. between neutral points. It is obvious therefore that, even with this higher peripheral speed of the commutator, there was undue crowding of the brush-holders; itself a bad feature. But the worst feature was that, with only 7 in. between the commutator neutral points, the permissible number of commutator bars was unduly limited. In consequence, 60-cycle converters for 250 to 300 volts rendered better service than 600-volt machines.

The field flux distribution had something to do with the questionable operating conditions. With these earlier machines, very high peripheral speeds of the armature core were considered objectionable for several reasons. One was, that the constructions did not allow very high peripheral speeds of the armature windings, and a second was that, with the relatively low speeds and large number of poles, the armature dimensions and cost would have been excessive. In general, a 12-in. pole pitch was considered as large as desirable or practicable, which corresponds to 7200 ft. per min. at 60 cycles.

With this small pole pitch, in order to obtain a sufficiently wide commutating zone between the poles, it was necessary to make the poles relatively narrow. The use of narrow poles led into one difficulty, as regards flashing, while widening the pole and narrowing the interpolar space led to another difficulty of flashing which was equally serious. An obvious remedy was in the use of wider pole pitches, but increasing the pole pitch, with a given number of poles and given speed, meant increasing the diameter of the armature, and, even though the armature could thereby be narrowed, the cost of the larger-diameter machine would necessarily be increased. The remedy for this condition was a reduction in the number of poles as the pitch was increased, thus keeping down the size of the armature for a given output. But reduction in the number of poles means higher speeds, which were formerly considered commercially objectionable. Therefore, between commercial limitations, difficulties in design and manufacturing conditions, the 60-cycle converter was in a bad way.

Attempts were made from time to time to increase the speed by decreasing the number of poles, but this could only be done commercially in relatively small steps. However, with increased experience in commutator constructions, one great advance was made by increasing the commutator speeds of the 60-cycle machines. Instead of approximately 7 in. between points, the distance was increased to 8½ or 9 in. for 600 volts, giving 5100 to 5400 ft. peripheral speeds at the commutator. This allowed as many as 45 to 48 commutator bars per pole, which is well within the range of good 600-volt practice. This reduced the average and the maximum volts per bar, and one of the principal weaknesses of the former designs was eliminated. Also, by improved mechanical design which allowed higher peripheral speed of the armature windings, the pole pitch could be increased to about 16 in., instead of 12 in., without an unduly large diameter of armature. This also allowed a much better field flux distribution, and better interpolar space.

With increased speed and decreased number of poles, the current per brush arm on the larger 60-cycle machines has gradually increased until it is practically double that of former practice. This higher current per arm, with the increased number of commutator bars per pole, and the higher speeds, all tend toward making the commutation more difficult. But at this stage in the development, the commutating pole began to loom up as a possibility in rotary converters, and this has furnished the latest important step, making still higher revolutions permissible.

With these higher speeds, and greater outputs with a given diameter of machine, the losses have not increased anything like in proportion, so that the efficiencies of the 60-cycle converters have been increasing until now they closely approach the 25-cycle machines. In fact, when the greater efficiency of the 60-cycle step-down transformers is considered, the difference in units of large capacity is small.

Commutation

There were a number of other minor conditions in these earlier machines which might be considered as mechanical defects, or mechanical and electrical combined. These were found principally in the brush-holder and commutator construction, and in the materials of the

*From a paper read before the Association of Edison Illuminating Companies.

commutator. On the higher-voltage machines, in which a large number of commutator bars per pole was necessary, the thickness of each bar was, and still is, very small, and the proportion of thickness of mica between bars to the thickness of the bars is considerable. On this account, it has been difficult to obtain a wear or abrasion of the mica equal to the so called copper wear. No matter how perfect the commutation may appear there is always a slight tendency to burn the face of the commutator by the current passing between the commutator and the brushes. This may be extremely slow, but if the mica does not wear down at the same rate it will lift the brush surface away from the copper, and thus an almost infinitesmal gap exists between the brush, and the commutator. This gap then exaggerates the burning tendency, and the difficulty is accentuated. This trouble is also accentuated by high commutator peripheral speeds. Hence, in 60-cycle rotary converters, in general, and in high voltages in particular, experience has shown that it is advisable to undercut the mica slightly, to avoid any tendency toward high mica, and also to be able to use brushes which contain some lubricant, such as graphite. Where any considerable grinding action by the brushes is necessary to keep down the mica, such lubrication is not practicable to the same extent.

Hunting

In the development of the 60-cycle rotary converter, there were other conditions beside commutation, flashing, etc., which had to be taken into account. The rotary converter is a synchronous machine, and must follow rigidly in step with the impressed electromotive force. The early machines in many cases, were operated from generators driven by slow-speed reciprocating engines, which did not run at uniform speed. As the engines and generators varied in speed periodically the frequency of the electric circuit varied to the same extent, and any synchronous apparatus operated on the system would also vary in speed. If the converter did not follow rigidly, it would hunt, the direct result of which was visible in bad operation at the commutator. In the normal rotary converter, when running properly in synchronism, there is practically no armature reaction such as is found in direct-current machines, for the alternating current supplied to the armature winding is in opposition to, and practically neutralizes, the magnetizing effect due to the direct current delivered. Therefore, as far as reactions on the field are concerned, it is quite different from a direct-current machine, and at full load, the armature has very little more effect on the field than at no load. However, when the converter is hunting, the current due to the hunting action is not balanced by the direct current delivered, so that this current acts like that in a straight alternating-current or direct-current machine, and sets up magnetic fluxes in the interpolar space, and under the edges of the poles, which are harmful. These fluxes create bad commutating conditions. Therefore, as a rotary converter hunts, there is usually periodic sparking at the brushes, which may become so bad that the machine flashes over. The corrective now universally applied consists in the use of copper dampers, or "cage windings," in the field pole faces.

The advent of the later 60-cycle turbo-generating plants has been a large factor in the successful development of 60-cycle converters. The problem of angular variation in speed of the prime mover has disappeared, and, therefore, the dampers on modern 60-cycle converters have to take care of only those secondary causes of hunting, which were present under the old conditions. Also, with the new high-speed machines having relatively wider poles, it is practicable to add many more damper bars per pole than in the older machines.

Commutating Poles

However, a new problem in hunting has come up in connection with the advent of the commutating pole, both in 25 and 60 cycles. In the commutating-pole generator, the ampere turns in each commutating-pole coil is sufficient to not only neutralize the entire magnetizing force of the armature winding per pole, but to also furnish an excess flux for commutating. In the commutating-pole converter, there is normally but little resultant magnetizing effect in the armature winding, due to the alternating and direct currents being normally in opposition, and, therefore, the commutating-pole winding must only be strong enough to neutralize the very small resultant armature reaction and give, in addition, a magnetic flux sufficient for commutation. In consequence, the ampere turns on the commutating-pole winding may be only 30 to 40 per cent. of the total armature-ampere turns, considered as in an alternating- or direct-current machine; whereas, in a direct-current generator, the commutating-pole winding is usually at least 125 per cent. of the armature-ampere turns. Therefore, the rotary converter cannot act as a generator or motor with good commutation, as its commutating-pole strength is then much less than required. As a generator or motor, the armature reaction may not only overpower the commutating-pole winding, but may set up a strong magnetic flux in the wrong direction, and render the commutating conditions worse than if the commutating pole were absent.

Herein lies a source of possible trouble with commutating-pole converters. In case there is hunting, the armature will act alternately as a generator and motor, and the magnetizing force of the armature may be such that it will demagnetize the commutating pole, or even reverse the flux under it, so that the machine acts in the same way as if it were operating with the current reversed in the commutating-pole winding, which would obviously give very bad commutating conditions. Therefore, when the commutating-pole converter hunts, it represents a worse condition than when a noncommutating-pole machine hunts to an equal extent. Hence somewhat better damping conditions are required than in the noncommutating-pole machine.

A new condition also developed in connection with self-starting of commutating-pole converters. In the older 60-cycle machines, starting motors were commonly used. Later practice tends toward self-starting, except in special cases. There are some advantages in this self-starting, and at the same time disadvantages, especially in the 60-cycle machines. The greatest advantage lies in the rapidity with which the converter can be started from rest and brought up to synchronism, together with the fact that no synchronizing devices are required. With the old starting motor, the machine had to be brought to synchronous speed and then thrown in step. This was more difficult with 60 cycles than with 25 cycles, and self-starting eliminates this trouble. On the other hand, while starting and accelerating, the rotary converter acts as an

induction motor and will take a relatively large starting current at very low power factor.

However, the new condition which developed with the advent of commutating poles, lies in sparking, and not in the starting current. As the rotary converter at the start acts like an induction motor, it has a rotating magnetic field flux set up, which travels around the armature. The armature coils short-circuited by the brushes form secondaries to, or are cut by, this field and, therefore, have relatively large electromotive forces set up in them, which develop large local currents. The electromotive forces set up in the short-circuited coils are usually somewhat greater in the 60-cycle converters than in 25-cycle machines, due to fewer conductors in series, and, therefore, the normal voltage per conductor is relatively higher than in the 25-cycle machines. Hence, at the start, the relative voltage per conductor generated by the rotating field set up by the armature winding will also be higher in the 60-cycle converter. Also, the number of commutator bars covered by the brush will usually be greater. Therefore, the short-circuiting action of the brushes and the sparking will be worse on the 60-cycle machines, but it is liable to be excessive on all large machines.

With the advent of the commutating-pole rotary converter, a still more difficult condition has been encountered in self-starting, namely, that the flux conditions in the zone of commutation of the short-circuited coils are materially higher than in the noncommutating-pole machine. In the latter type, while the short-circuited coils cut an alternating flux and therefore have local currents set up in them, these coils, in commutating or reversing these currents, lie midway between the poles, and therefore in the region where the conditions of reversal are easiest. But in placing the commutating pole directly over the short-circuited coils, the conditions of reversal of the short-circuited current are made much more difficult during starting. In consequence, during starting and accelerating, the sparking conditions in the commutating-pole type, both for 60 and 25 cycles, are much worse than in the older noncommutating-pole type. In fact, in the larger machines, the conditions are so bad that it has been found necessary to add brush-lifting devices which will lift all the brushes but two, during starting and bringing up to speed.

Voltage Variation

In the earlier 60-cycle machines the question of variable voltage came up in connection with 250- to 300-volt machines. The general means of voltage variation in these machines was almost entirely by means of induction regulators, or transformers. It is only in very recent years that the self-contained units, such as the synchronous-booster rotaries, and the regulating-pole type, have been brought forward. For 60 cycles, the synchronous booster appears to be the only really practical method, due largely to limitations in design and in space requirements. If commutating poles are to be used, then the regulating-pole type of machine, with main and auxiliary poles in addition to the commutating poles, requires a very crowded design of field, unless a larger pole pitch is chosen than in the synchronous-booster machine, in which there are only the commutating and the main poles.

Sixty-cycle rotary converters are now being manufactured in relatively large capacities, such as 1000, 1500 and 2000 kw. for 270 volts with synchronous boosters, and up to 2500 kw. for higher voltages. Larger capacities, for either voltage, can be constructed without difficulty, and with as good performance as in the capacities mentioned.

Diesel-Electric-Driven Ship

By J. R. Wilson

Perhaps one of the most interesting ships of the year is the "Tynemount," a vessel built to demonstrate the advantages of electric transmission in connection with the Diesel engine for the propulsion of large ships. Built for the Montreal Transportation Co., this vessel, which is of 2400 tons displacement, is equipped with two four-stroke-cycle, six-cylinder, 300-hp. Diesel engines driving three-phase alternators at 400 r.p.m.; the latter in turn supply a 500-hp. electric motor which drives a single propeller.

The engines are both divided into groups of three cylinders, and the camshaft of each is driven by a vertical shaft arranged between the two groups. The bedplate is cast in two pieces and bolted together, and joined with the alternator bedplate at the flywheel end of each engine.

Starting is effected by means of compressed air, three cylinders only being fitted with starting valves. A device for stopping the engine and means of controlling the amount of air delivered by the air compressor are also provided on the control pillar. Near at hand is the electric controller of the transmission system, the whole providing a compact and centralized arrangement for the operation of the propelling machinery; controls are also carried to the bridge. At the after end of each engine a three-stage air compressor is fitted, driven direct from an extension of the engine crankshaft. This extension also provides means for driving the lubricating and circulating-water pumps. The fuel pumps are driven by eccentrics from the camshaft.

The electrical equipment consists of two three-phase alternators, each coupled direct to one of the Diesel engines. These alternators, when running at their normal speed of 400 r.p.m., have an output of 270 amp. each per phase at 500 volts which absorbs the full power of the engine. One is provided with six and the other with eight poles, giving frequencies of 20 and 26.6 cycles respectively. An exciter is coupled direct to each alternator and is capable of giving an exciting current of 30 amp. for ample working, which can be increased up to 50 amp. while maneuvering.

These two generating sets supply a 500-hp. induction motor of special construction. The rotor is of the squirrel-cage type, but the stator is provided with two different and entirely separate windings, one of 30 and the other of 40 poles. When these two windings are supplied with current at 20 and 26.6 cycles respectively, they give the same synchronous speed of 80 r.p.m. The motor will then absorb the full power of both engines and drive the propeller at 78 r.p.m. This propeller speed corresponds to the fastest speed of the vessel.

In order to obtain a slower speed the connections are altered so that the 20-cycle alternator supplies the 40-pole winding of the motor; the 26.6-cycle alternator can be shut down and the 30-pole winding of the motor is

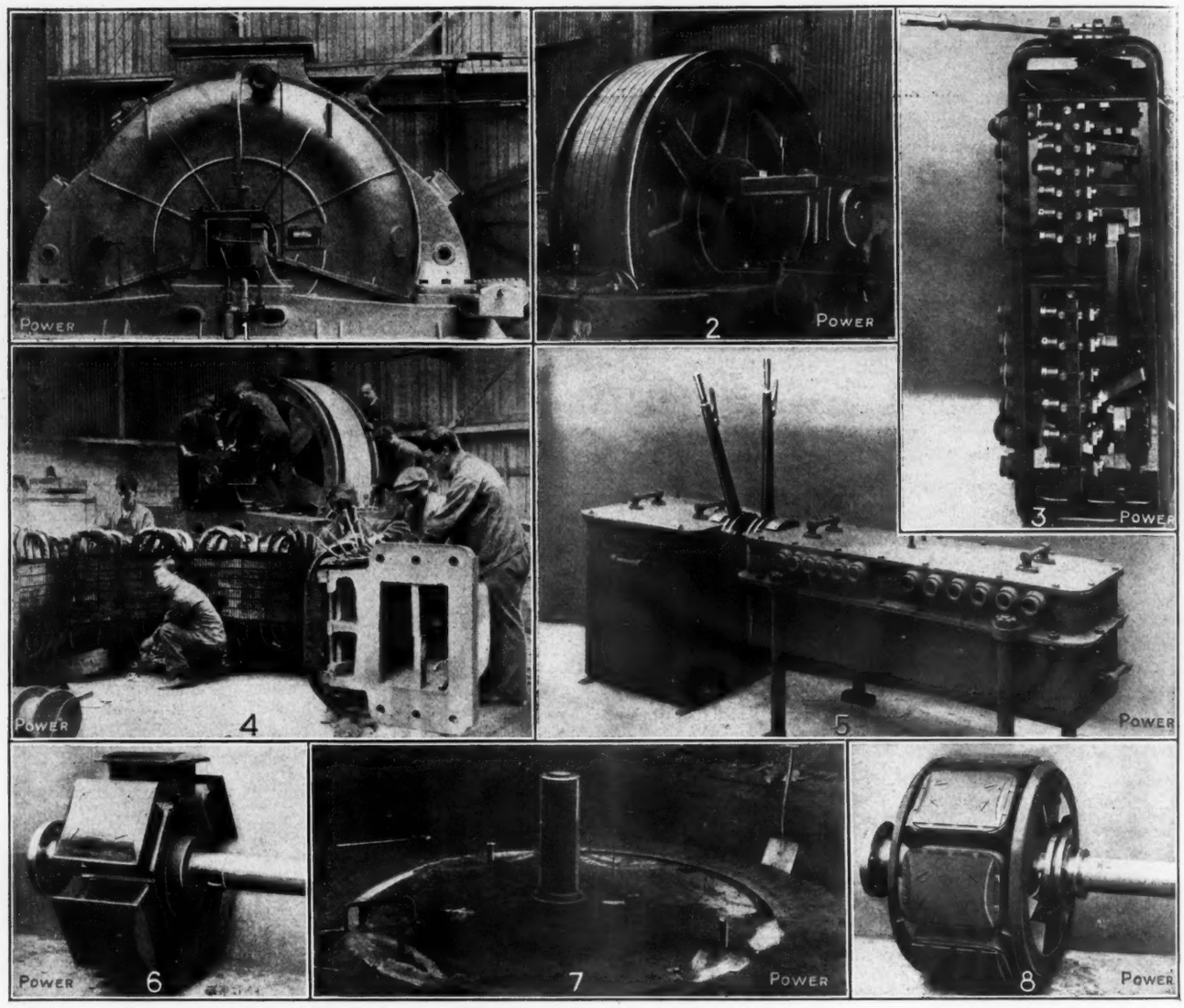


Fig. 1, motor complete; Fig. 2, rotor of motor in position; Fig. 3, main switch with cover and oil tank removed; Fig. 4, stator of motor in course of winding; Fig. 5, main switch and exciter switch with interlocking gear; Fig. 6, rotor of six-pole alternator before winding; Fig. 7, rotor of motor in foundry ready to cast on end rings; Fig. 8, rotor of eight-pole alternator.

also out of service. The synchronous speed of the motor with the propeller is now reduced to 60 r.p.m. One of the engines only is available, but as the speed of the ship is reduced to about three-quarters normal, half of the total horsepower is ample and the great advantage is obtained of being able to entirely shut down that part of the plant which is not required at low speed. It will be noticed that the two alternators, when both are at work, are connected to entirely separate circuits and they are therefore never run in parallel. The process of paralleling would be quite unsuitable on shipboard as this operation not only requires skill and care but would involve considerable delay in starting the propeller motor.

Reversing is carried out by interchanging the connections of two phases. The switch gear provided for this purpose is extremely simple, consisting of two parts: a main switch of the tramway controller type having five different positions—full ahead, half ahead, stop, half astern and full astern, and of a second switch, the purpose of which is to introduce resistance into the shunt circuit of the exciter.

The contacts of both switches work under oil, but it is inadvisable that the contacts of the main switch should

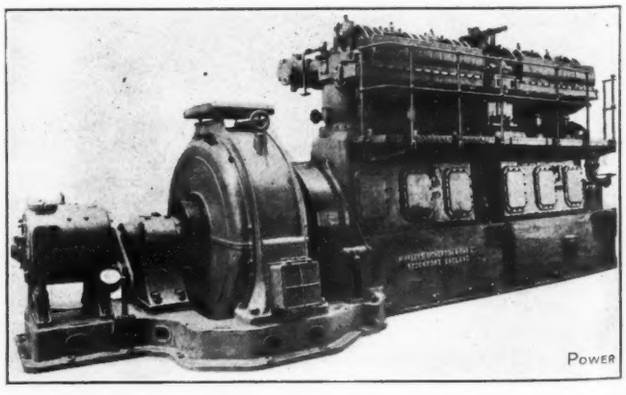


FIG. 9. GENERATING UNIT COMPLETE

be required to break the large main current flowing to the motor. The two switches are, therefore, interlocked so that it is impossible to work the main switch except when all the resistance has been introduced into the exciter field coils. There is then practically no excitation and the whole system is dead. With the resistance in the exciter field circuit, the main switch can be moved

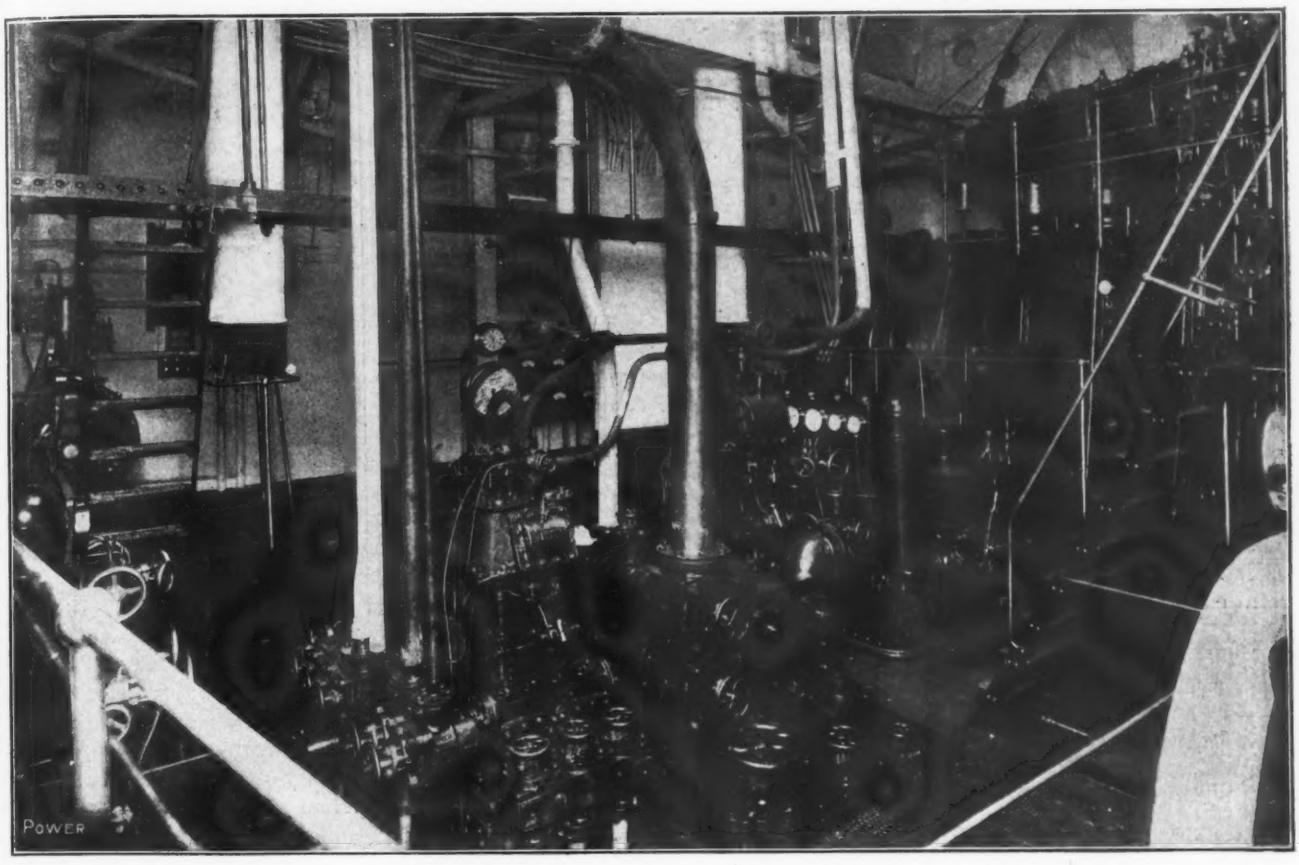


FIG. 10. GENERAL VIEW OF ENGINE ROOM, SHOWING ONE GENERATING UNIT AND CONTROL GEAR

to any one of its four working positions, and when the main connections have been made for the new running position the shunt-switch lever is pulled over so as to cut out the resistance and restore the excitation. Until the main switch is definitely on one set of contacts the shunt switch is locked so that the excitation cannot be restored. It will be seen that the whole handling of the ship can be carried out by means of two levers which are so interlocked as to be practically foolproof.

CORRESPONDENCE

Putting Tirrell Regulator in Service

Referring to Mr. Randolph's article in the Oct. 7 issue, on the Tirrell regulator, in my opinion his method of putting the instrument into service can be improved. To lower the line voltage to 65 per cent. below normal every time the instrument is put in operation, which is necessarily frequent in order to maintain the good condition of the contacts, would hardly make for good service. The following method has been found to raise the least disturbance and in fact it is impossible to detect when the regulator is being taken out or put back.

The single-pole switches at the top of the panel, connecting the control solenoids with the alternating current line and the exciter busbar are closed first in order to note the position of the main contacts. If they are closed, and consequently the relay contacts, to close the shunt-circuit switches which connect the latter with the taps on the exciter rheostat, would short-circuit the rheostat. This would cause more or less fluctuation in the line. If, however, the exciter voltage is raised slightly (but one or two volts being sufficient) the contacts will open. This rise is so slight as not to be apparent in the line.

The relay contacts being open, the shunt-circuiting switches may be closed without affecting the system. If the exciter voltage is now lowered about as much as it was raised, the regulator will swing into action slowly and smoothly. The rheostat can now be cut into the desired point, the only noticeable effect being a speeding up of the regulator.

On taking out the instrument, the reverse course is taken. By turning out the rheostat slowly, the speed of the contacts become slower until they stop, remaining open. The shunt-circuit switches can be opened and the regulator cut out of service for cleaning by opening the top switches.

L. W. CULTER.

Union Hill, N. J.

Erection of Stettin Electric Plant—The Kraftwerk Stettin, the company which furnishes electric current to the consumers in Stettin, Germany, and vicinity, is erecting a second plant, in order to supply the constantly increasing demand. When first erected the present plant had a capacity of 9,000,000 kw.-hr., which was increased to 12,000,000 by adding to the plant. The demand of large and small consumers will compel the production of 18,000,000 to 20,000,000 kw.-hr. in the near future. The new plant is to take care of this increase. Machinery of 12,000 to 15,000 hp. will be installed at once, but the plans are so arranged that it can be increased to 50,000 hp. When completed Kraftwerk Stettin will be one of the largest plants in Germany for the production of electric current. The buildings, to be located on the waterfront, will comprise boiler houses, engine rooms, and facilities for unloading and storing coal. Steam power will be used.

HEATING AND VENTILATION

Vacua Hot-Water Heating Applied to Woolworth Building*

By Ira N. Evans

From time to time articles have appeared presenting the feasibility of operating the power equipment of office buildings with condensing engines or turbines in connection with a cooling tower and a hot-water heating system under forced circulation, utilizing the exhaust steam under partial vacuum. It is the purpose of the present article to compare the operating economies of such an installation applied to the Woolworth Building with the present equipment of vacuum heating and noncondensing

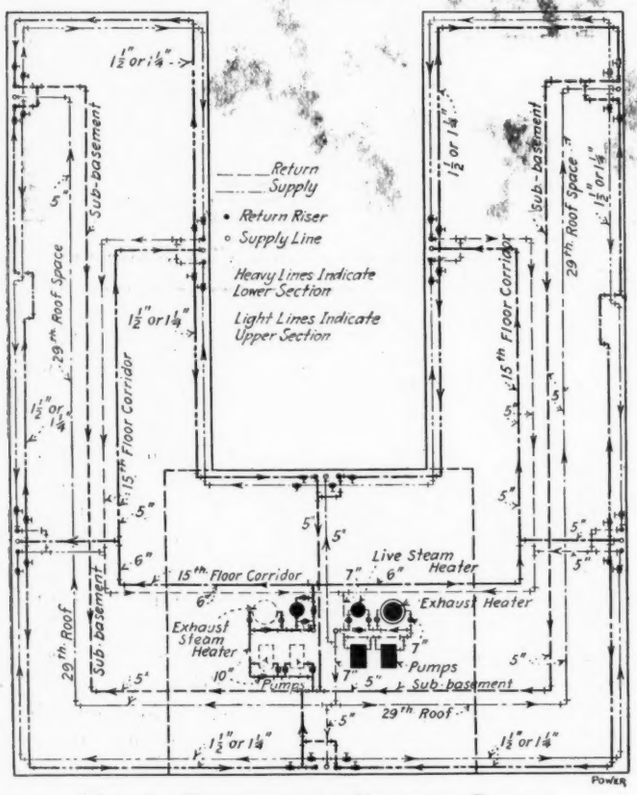


Fig. 1. Elevation of Proposed Layout

compound engines, as described in the June 24 issue of Power. It should be understood that criticism of present methods is not intended and that the proposed arrangement could only be applied to a building before construction. The subject can only be treated briefly, due to the allotted space, but discussion of this paper is invited in order to bring out any fallacy in the reasoning or design.

In view of the low dividends on investments in buildings of this class and the strides that have been made in the economy of condensing equipment and turbine construction, it is singular that these improvements have not been employed in this line of work. Turbines and condensers have not been successful under these conditions mainly on account of the fixed temperature and pressure required for the steam-heating system. The heating apparatus has a cooling capacity in winter equivalent generally to the average power load on the plant, which could be utilized at no expense if modified to suit the requirements of a variable temperature of the medium.

Central-station men are constantly giving out data showing the excess of the steam required for power over that required for heating, and using it as an argument for making contracts for central-station current. They are correct in some respects and their argument should be met by modifying the heating system as indicated in this paper rather than by reducing the engine economy to suit the heating system.

Due to its temperature range hot water is acknowledged, from a sanitary and economic standpoint, as the best heating medium, and in the proposed arrangement no greater radiation is necessary than for vacuum steam heating. The present system requires expensive pipe galleries and a 20-in. main dividing into an 18-in. for the main building and a 10-in. main for the tower. Large risers are required at each pilaster, to say nothing of the loss of space due to furring into the room to conceal them. The covering of mains and risers is an item as expensive as the piping.

In this particular building a condensing apparatus is provided at considerable expense in operation and first cost merely to reduce the appearance of the exhaust steam on the roof. This apparatus would be entirely inadequate to produce any vacuum on the engines even if the piping system could be made air-tight, which would be next to impossible on so large a system.

The description states that all returns are brought to a vacuum pump. If the returns from the upper stories were reduced in size the falling water would produce ample vacuum. It would be possible with a rotary air pump to return all condensation from the tower by gravity to the boilers direct. The pump, motor driven in the upper stories, would not be required to handle any water at all. If the twenty-ninth floor was 350 ft. from the water level of the boilers the head would be equivalent to 150 lb. pressure.

The direct radiation is given as 104,000 sq.ft., which will be used throughout this discussion, and 178,000 cu.ft. of air are required for ventilation, this amount being heated from the outside temperature to 70 deg. Two comparisons of steam and hot-water heating will be made, one including ventilation and the other without the ventilation. In the latter case 10 per cent. will be added the direct radiation to make up for the elimination of the air supply. This method is followed, as few of these buildings have provision for extensive ventilation and it is desired to make the comparison as broad in its application as possible.

For air supply and exhaust the total air handled is

*Copyrighted, 1913, by Ira N. Evans.

given at 417,000 cu.ft. per min., and assuming that 1500 cu.ft. will require 1 hp., 279 hp. or about 200 kw. will be the power load for these motors. For the power load without ventilation 150 kw. will be deducted. Table 4 gives the number of hours for each assumed load for the year with and without ventilation and therefore the total kilowatt-hours. The data were assumed partly from the units installed and the power loads given and are intended for the condition when the building is well occupied. A complete shutdown of 2 to 3 hr. is provided at night, which will deduct about 1000 hr. from the total period of operation. The load factor is given as 32 per cent. when ventilation is included and 27 per cent. without. The holiday and night load in winter may be disregarded as the heating at all times will require more steam than would be furnished by the power load. The fresh-air supply is only considered to be in operation during the 1545 hr. in winter and 1100 hr. in summer, the night-heating load including only the direct surface. The above table of hours was made up from the weather-bureau reports and the calendar; and allowances made for the half holiday Saturday and Sundays, with a 10-hr. working day.

Figs. 1 and 2 give the general arrangement of piping and mains for the main building and tower, the heavy lines indicating the lower section and the lighter lines the upper section. The heaters filled in on Fig. 1 are on the fifteenth floor while those in dotted lines are in the basement. The hot-water system is thus divided into four sections. All connections to exhaust heaters would be made from the main exhaust to the roof. This main would require an automatic relief valve at the top and would have to be made air-tight, although not over 23 or 24 in. maximum of vacuum would be carried, as in summer this line, except for relief purposes, would be shut off.

Each riser has two returns and one supply. There are four supplies to each section in Fig. 1 with a 1¼-in. or 1½-in. pipe along the base at each floor from which the radiators are shunted. Each of these lines will have up to 700 sq.ft. of surface and be uncovered. A valve at each end and a permanent drawoff so subdivide the heating system that without interference with the operation of the remainder, only a comparatively small section need be drawn off at one time.

This arrangement brings a supply for the lower section and return from the upper section in the fifteenth-floor corridor, a 5-in. supply for the upper system in the roof space and a 5-in. return in the basement or sub-basement for the lower section. The largest main for the upper section would be 7 in., for the lower section with the indirect, 10 in., and the supply for both sections in the tower would be 5 in. The heaters for the tower would be at the fortieth floor with a similar arrangement of mains.

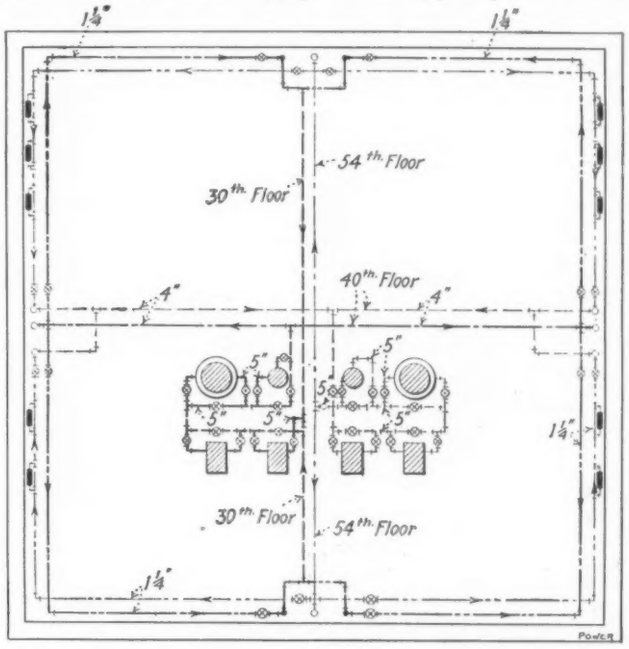


FIG. 2. PLAN OF HEATER AND PUMP CONNECTIONS

TABLE 1. DAY HEATING AND POWER WITH VENTILATION (1545 HR.)

Outside Temp. Periods	Hours Each Period	Per Cent. Max. Load	Vacuum In.	Steam Rate 500-Kw. Turbine	Lb. Steam per Hr. for Heating, 40,000 × Col. C.	Kw. Load to Balance Heating F ÷ E	Total Probable Load on Red. Vac., Kw.	Heating Steam per Hour from Power, lb., H × E	Heating Steam for Each Period, lb., I × B	Total Kw.-Hr. on Heating H×B
A	B	C	D	E	F	G	H	I	J	K
0—10	10	92	0	42	36,000	876	900	37,800	378,000	9,000
10—20	50	82	6.4	38	32,800	863	900	34,200	1,710,000	45,000
20—30	205	72	11.5	34.5	28,800	834	900	31,050	6,365,250	184,500
30—40	500	62	17	30.2	24,800	821	900	27,180	13,590,000	450,000
40—50	350	51.7	22	26.5	20,680	780	850	22,525	7,883,750	297,500
50—60	430	38	26	22.5	15,200	676	750	16,875	7,256,250	322,500
									37,183,250	1,308,500

TABLE 2. NIGHT HEATING WITH HOT WATER, DIRECT RADIATION ONLY

Outside Temp. Periods	Hours Each Period	Av. Temp. Water Deg. F.	Temp. Water Less 70°	Lb. Steam per Hr. $\frac{104{,}000 \times 1.7}{1000} = \frac{176.8}{176.8 \times \text{Col. E}}$	Steam for Each Period Lb. B × F
A	B	D	E	F	G
0—10	56	200	130	22,984	1,287,104
10—20	214	190	120	21,216	4,540,224
20—30	624	176	106	18,741	11,694,384
30—40	971	163	93	16,442	15,965,182
40—50	781	143	73	12,906	10,079,586
50—60	354	122	52	9,200	3,256,800
Total....	3000				46,823,280
				10 per cent.	4,682,328
				Total,	51,505,608

Each heater room would be carried through two stories with a space of about 20x10 ft. This could be found adjacent to the traction elevator machines. All pumps would be motor driven and arranged as shown. All heaters, both live and exhaust steam, on the fortieth floor, and the live-steam heaters on the fifteenth floor, would be arranged to return the condensation to the boilers by gravity. Possibly a dry-air pump may be needed for the exhaust heaters on the fortieth floor, but the exhaust heater on the fifteenth floor would be operated in conjunction with the condensing apparatus.

This arrangement of mains will eliminate the pipe galleries entirely and may be likened to a system having the mains running vertical with the pipes corresponding to the risers horizontal. In Figs. 1 and 2 two lines are shown, but they represent one for the upper and one for the lower section, there being only one at each floor in

any case. The temperature of the heating medium will be regulated in all cases by varying the vacuum and can be done entirely from the basement. Only eight pilasters are required to be furred and the risers will be 5 in. reducing to 2 in. Covering is necessary only on the horizontal mains, heaters and perhaps the vertical risers. All runouts, 1½ and 1¼ in. may be left uncovered, concealed or exposed as desired. They may be used for heating surface as the water temperature is changed to suit outside weather conditions, while the steam system has a nearly constant temperature for all surface turned on.

The cooling tower for 1000 kw. capacity would take a space in the basement or upper floor of 20 ft. in height and two diameters of 18 ft. This could not be placed on the roof as the head would be too great for the condenser and circulating pumps, although not impossible. It could be rigged in conjunction with the outlet for the exhaust ventilation which would reduce the size of cooling tower and cost nothing for air circulation. Its location might be in the basement with a flue leading to the roof.

All water for the hot-water service, air washing and that necessary for flushing closets could be taken from the circulating line to the cooling tower, thus reducing the city water necessary for condensing purposes by a considerable amount. A driven well of small capacity would also answer even if the water was unfit for feed purposes. These operations combined would reduce the water bill appreciably. The turbines and condensers would occupy only about one-quarter of the space provided for the reciprocating engines, although on the whole the total space occupied by the generating units and hot-water condensing equipment will be about the same as for the engines and steam system. The required space, however, could be in less valuable sections of the building, such as spaces adjacent to corridors or elevators.

With a transmission of 1.7 B.t.u. per sq.ft. per deg. difference, Table 2 gives the steam for hot-water night heating, with the direct radiation only, as 46,823,280 lb. for 3000 hr. Adding 10 per cent. to this gives as the steam requirements for the hot-water system without ventilation 51,505,608 lb. for the same interval. The load on the steam system will be taken at 24,000 lb., and 26,400 lb. per hr. with and without the ventilation and with a load factor of 75 per cent., which is low. Thus

$$24{,}000 \times 0.75 \times 3000\ hr. = 54{,}000{,}000\ lb.$$
$$26{,}400 \times 0.75 \times 3000\ hr. = 59{,}400{,}000\ lb.$$

Table 1 gives the heating load on the hot-water system with ventilation and the steam consumptions on a 500-kw. turbine with an hourly load that will exactly balance the heating for 1545 hr. The maximum load days with ventilation is as follows:

Direct Rad.:

$$104{,}000\ sq.ft. \times 1.7\ B.t.u. \times (210 - 70) = 24{,}752{,}000\ B.t.u.$$

Air supply:

$$\frac{178{,}000\ cu.ft.}{50\ cu.ft.} \times 60\ min. \times 70\ deg. = 14{,}952{,}000\ B.t.u.$$

$$39{,}704{,}000\ B.t.u.$$

The maximum load will be taken as 40,000 lb. of steam and percentages used in Table 1 give the proportion for each outside period and length of time. A summary of Table 1 is that 1,308,500 kw.-hr. are obtained from 37,183,250 lb. of steam for 1545 hr.

TABLE 3. DAY HEATING AND POWER WITHOUT VENTILATION (1545 HR.)

Outside Temp. Periods	Hours Each Period	Per Cent. Max. Load	Vacuum In.	Steam Rate 500-Kw. Turbine	Lb. Steam per Hr. for Heating, 27,000 × Col. C.	Kw. Load to Balance Heating F ÷ E	Total Probable Load on Red. Vac., Kw.	Heating Steam per Hr. from Power, lb., H × E	Heating Steam for Each Period, lb. I × B	Total Kw.-Hr. on Heating H × B
A	B	C	D	E	F	G	H	I	J	K
0—10	10	92	0	42	24,840	591	650	27,300	273,000	6,500
10—20	50	82	6.4	38	22,140	582	600	22,800	1,140,000	30,000
20—30	205	72	11.5	34.5	19,440	563	600	20,700	4,243,500	123,000
30—40	500	62	17	30.2	16,740	554	600	18,120	9,060,000	300,000
40—50	350	51.7	22	26.5	13,959	527	550	14,575	5,101,250	192,500
50—60	430	38	26	22.5	10,260	456	500	11,250	4,837,500	215,000
									24,655,250	867,000

Table 3 gives the same data for a hot-water system with no ventilation. The result here is 867,000 kw.-hr. for 24,655,250 lb. of steam. The heating systems of these buildings are operated continuously in most cases as it is desirable to keep the system free from air, as well as to avoid the expense of heating up in a short space of time. As a result radiators are left turned on and windows opened due to overheating, thus increasing the heating load. All the water has to be handled by vacuum pumps and boiler-feed pumps at some expense during periods of power load when a surplus of exhaust steam is available. The gravity return of condensation on the hot-water system and ease of regulation of the heating medium does away with these losses, but no credit is allowed in the operating expense.

TABLE 4. POWER LOADS

Periods	Total Hours Each Period	Power Load with Ventilation: Hours Service Each Period	Kw. Load	Total Kw.-Hr.	Kw.-Hr. When Power Is in Excess Heating	Load without Ventilation: Kw. Load	Total Kw.-Hr.	Kw.-hr. When Power Is in Excess Heating
Peak load winter	600	1545	1300	780,000	1,725,000	1150	690,000	1,493,250
Average day load winter	945		1000	945,000		850	803,250	
Holiday and night load winter heat in excess power	3491	3000	300	900,000		250	750,000	
Summer day load	1100	1100	900	990,000		750	825,000	
Summer night load	2310	1800	300	540,000	1,592,000	250	450,000	1,337,000
Summer holiday load	310	310	200	62,000		200	62,000	
Totals	8756	7755		4,217,000			3,580,250	

$$\frac{4{,}217{,}000}{8756 \times 1500} = 32.1\%\ \text{load factor} \qquad \frac{3{,}580{,}250}{8756 \times 1500} = 27.26\%\ \text{load factor}$$

The hot-water system will lend itself to intermittent operation easier than the steam system, as all that is necessary is to turn steam on the heaters and start the pumps. The turbines require no cylinder oil, thus eliminating all muffler tanks, pumps, receivers and oil-separating apparatus on the main units.

For different vacuums the steam consumption on the turbine is given in Tables 1 and 3. No work is required of the condenser further than regulating the vacuum and preventing the heating medium from becoming overheated. For the reciprocating engine 35 lb. per kw.-hr. is taken as the steam consumption, and 24 lb. for the turbine under 27 to 28 in. of vacuum.

From Tables 1, 3 and 4 it may be seen that from 300 to 500 kw. can be operated at full vacuum over a large part of the time. In Table 1, 900 kw. is required for heating under partial vacuum while Table 4 gives 1000 to 1300 kw. as the power load. In Table 3 it is shown that 600 kw. is required for heating while 250 to 550 kw. could be operated on full vacuum.

For circulating the water in the hot-water system, 10 hp. will be required for each of the tower systems, 50 hp. for the lower section with the ventilation and 30 hp. for the upper part of the main building, making 100 hp. in all, or 75 kw. Nothing is lost in using the power to circulate the water as the mechanical work is all returned in heat, due to friction. The pumps work against only the friction head, due to the velocity of the water; and the exhaust is utilized in the heater. It is, however, live-steam operation when there is a surplus of steam from other sources. To make the comparison conservative the entire pumpage for the water system will be charged and no allowance made for the steam used by the vacuum pumps during the same period on the steam system, although they use about 120 lb. per hp.-hr. The pumpage, however, will be charged at the full vacuum rate of 24 lb. per kw.-hr. At night the cost of pumping will be nothing, due to an inadequate supply of exhaust steam. The day steam for pumping would then be

$$1545\ hr. \times 75\ kw. \times 24\ lb. = 2{,}781{,}000\ lb.$$

of steam. In charging the water for the condensing system a pound of water will be used per pound of exhaust steam condensed at a cost of $1 per 1000 cu.ft. The loss on the steam system will be all that is not required for heating, as it will go to the atmosphere.

In Table 4 the kilowatt-hours of power for the winter day load is given as 1,725,000 and for the total summer load as 1,592,000. The rate per kilowatt-hour for the engines was previously given as 35 lb., so that the total steam consumption would be

1,725,000 × 35 =	60,375,000 lb.
1,592,000 × 35 =	55,720,000 lb.
Total	116,095,000 lb.

A charge of $3.50 will be allowed for fuel, ash handling, etc., and an evaporation of 8 lb. of water per pound of coal. Then

$$\frac{116{,}095{,}000}{8 \times 2000} = 7256\ tons$$

Night heating on direct radiation only for 3000 hr. will amount to

$$24{,}000 \times 0.75 \times 3000 = 54{,}000{,}000\ lb.$$

$$\frac{54{,}000{,}000}{8 \times 2000} = 3375\ tons$$

The water used may be totaled up as follows:

	Pounds
For winter day power load	60,375,000
Heating (1545 hr. at 75 per cent. of 40,000 lb. per hr.)	46,350,000
Difference	14,025,000
Summer load	55,720,000
Total	69,745,000

Reducing the above total to cubic feet and deducting 10 per cent. for feed gives

$$\frac{69{,}745{,}000}{62.5} = 1{,}115{,}920\ cu.ft.$$

$$1{,}115{,}920 - (0.10 \times 1{,}115{,}920) = 1{,}004{,}328\ cu.ft.$$

At $1 per 1000 cu.ft. the water bill would amount to $1004, for the exhaust steam wasted to the atmosphere. The total charge for coal and water would be:

7256 tons at $3.50	$25,396
3375 tons at $3.50	11,812
Water	1,004
Total	$38,212

Referring to Tables 1, 2 and 4 the cost of coal and water for the hot-water system with ventilation may be figured in much the same way. For the winter day load it is shown in Table 1 that there are 1,308,500 kw.-hr. on the heating which require 37,183,250 lb. of steam. Then as the total load for this period is 1,725,000 kw.-hr., steam from

$$1{,}725{,}000 - 1{,}308{,}500 = 416{,}500\ kw.\text{-}hr.$$

will go to the condenser and cooling tower. The total weight of steam will then be

	Pounds
1,308,500 kw.-hr.	37,183,200
416,500 kw.-hr. at 24 lb.	9,996,000
1,592,000 kw.-hr. at 24 lb. (summer load)	38,208,000
115,875 kw.-hr. at 24 lb. (pumpage)	2,781,000
Total	88,168,200

$$\frac{88{,}168{,}200}{8 \times 2000} = 5510\ tons$$

From Table 2 the steam for night heating amounts to 46,823,280 lb. In coal this would require

$$\frac{46{,}823{,}280}{8 \times 2000} = 2926\ tons$$

Water for the cooling tower, pound for pound, will amount to

	Pounds
416,500 kw.-hr. at 24 lb.	9,996,000
1,592,000 kw.-hr. at 24 lb. (summer load)	38,208,000
115,875 kw.-hr. at 24 lb. (pumpage)	2,781,000
Total	50,985,000

$$\frac{50{,}985{,}000}{62.5} = 815{,}760\ cu.ft. = \$816$$

Then, as before, the total charge for coal and water would be

5510 tons at $3.50	$19,285
2926 tons at $3.50	10,241
Water	816
Total	$30,342

The same computations are now made for the steam and hot-water systems without ventilation and allowing 10 per cent. more direct surface. From Table 4 the total weight of steam for the steam system will be

	Pounds
1,493,250 kw.-hr. at 35 lb	52,263,750
1,337,600 kw.-hr. at 35 lb	46,816,000
Total	99,079,750

$$\frac{99{,}079{,}750}{8 \times 2000} = 6192\ tons$$

Night heating on direct radiation for 3000 hr. at 75 per cent. load factor will amount to

$$26{,}400 \times 0.75 \times 3000 = 59{,}400{,}000\ lb.$$

$$\frac{59{,}400{,}000}{8 \times 2000} = 3712\ tons$$

The water is figured as in the previous case.

	Pounds
For winter day power load	52,263,750
Heating (1545 hr. at 75 per cent. of 26,400 lb.)	30,591,000
Difference	21,672,750
Summer load	46,816,000
Total	68,488,750

$$\frac{68{,}488{,}750}{62.5} = 1{,}095{,}820\ cu.ft.$$

Deducting 10 per cent. for feed leaves 986,238 cu.ft., giving $986 as the cost of the exhaust steam wasted to the atmosphere.

The total coal and water costs would then be

6192 tons at $3.50	$21,672
3712 tons at $3.50	12,992
Water	986
Total	$35,650

Following are the data for the hot-water heating system without ventilation. According to Table 4 the total winter day load is 1,493,250 kw.-hr.; from Table 3 the kilowatt-hours on heating are 867,000 and require 24,655,250 lb. of steam. Then

	Pounds
1,493,250—867,000 kw.-hr. at 24 lb	15,030,000
867,000 kw.-hr. (heating)	24,655,250
1,337,600 kw.-hr. at 24 lb. (summer load)	32,102,400
Pumpage, same as before	2,781,000
Total	74,568,650

$$\frac{74,568,650}{8 \times 2000} = 4660 \textit{ tons}$$

In Table 2 the steam for night heating is given as 46,823,280 lb. Adding 10 per cent. for the increased radiation makes this 51,505,608 lb. Then

$$\frac{51,505,608}{8 \times 2000} = 3219 \textit{ tons}$$

Water for the cooling tower is as follows:

	Pounds
1,493,250—867,000 kw.-hr. at 24 lb	15,030,000
1,337,600 kw.-hr. at 24 lb. (summer load)	32,102,400
Pumpage	2,781,000
Total	49,913,400

$$\frac{49,913,400}{62.5} = 798,614 = \$799$$

Adding the coal and water costs, as in the previous cases, gives the following total:

4660 tons at $3.50	$16,310
3219 tons at $3.50	11,266
Water	799
Total	$28,375

Table 5 gives a summary of the data and shows a saving of about 20 per cent. in the cost of coal and water in favor of the hot-water system. Undoubtedly the night operation on the hot water as against steam will show a much larger saving in practice. As the ventilation is not operative except during day periods, it would be of interest to see what it actually costs over direct radiation with hot water and condensing apparatus. Considering only the day operation the saving would be as follows:

	Coal Tons	Water 1000 cu.ft.	Cost Fuel	Total
Steam with vent	7256	1004	$25,396	$26,400
Water without vent	4660	799	16,310	17,109
Saving	2596	205	$9,086	$9,291
Per cent	35.8	20	35.8	35.2

Engineers quite generally recommend that as the exhaust steam is available from the power load, it may be used for ventilation without cost, which is not the case under condensing conditions. It, however, is not the purpose of this article to suggest the inadvisability of ventilation, but that it should be properly charged for.

The initial costs of the two systems would be in favor of the water system with the turbine equipment. The use of reciprocating engines would not change the percentage of saving, but the initial cost would be greater as well as the required space. The saving due to the use of condensing equipment is 24 per cent., and is not affected appreciably by the night heating load as at the time the exhaust steam is insufficient.

TABLE 5. SUMMARY OF RESULTS

Hot Water Condensing vs. Steam Noncondensing with Ventilation

	Coal Days Tons	Coal Nights Tons	Water 1000 cu.ft.	Cost Coal Days	Cost Coal Nights	Cost Water	Total Cost
Steam	7256	3375	1004	$25,396	$11,812	$1004	$38,212
Hot water	5510	2926	816	19,285	10,241	816	30,342
Difference	1746	449	188	$6,111	$1571	$188	$7870
Per cent. saving	24.1	13.3	18.7	24.1	13.3	18.7	20.6

Without Ventilation

	Coal Days Tons	Coal Nights Tons	Water 1000 cu.ft.	Cost Coal Days	Cost Coal Nights	Cost Water	Total Cost
Steam	6192	3712	986	$21,672	$12,992	$986	$35,650
Hot water	4660	3219	799	16,310	11,266	799	28,375
Difference	1532	493	187	$5,362	$1,726	$187	$7,275
Per cent. saving	24.7	13.3	19	24.7	13.3	19	20.4

Cost of Ventilation on Both Systems

	Steam Noncondensing: Coal Days Tons	Water 1000 cu.ft.	Cost Fuel	Cost Water	Total Cost	Hot Water Condensing: Coal Days Tons	Water 1000 cu.ft.	Cost Fuel	Cost Water	Total Cost
With	7256	1004	$25,396	$1004	$26,400	5510	816	$19,285	$816	$20,101
Without	6192	986	21,672	986	22,658	4660	799	16,310	799	17,109
Difference	1064	18	$3,724	$18	$3,742	850	17	$2,975	$17	$2,992
Per cent.	14.6	1.8	14.6	1.8	14.2	15.4	2.1	15.4	2.1	14.9

The results of the analysis show a reduction in necessary boiler power of 20 to 25 per cent., or at least 464 hp. A total of 2000 hp. would give as large reserve power as the present system with 2464 hp. The cost of piping and pipe covering on the water system would be considerably lower, notwithstanding that a supply and return of the same size are required on the water system. This difference will be assumed to be $5000 in favor of the hot-water system. The muffler tanks, vacuum pumps, oil-separating apparatus on the steam system are unnecessary with hot water and are included in the $5000 item.

Steam System		Water System	
1500 kw. in compound engine and generators of 100 r.p.m at $35 per kw. with foundations	$52,500	1500-kw. turbines and generators at $20	$30,000
2464 hp. in boilers at $20	49,280	Cooling tower and condensers, 1000 kw. at $20	20,000
Excess cost of piping and covering over water system	5,000	Heaters and pumps in hot-water system	15,000
3000 vacuum valves at $4	12,000	2000 hp. boilers at $20	40,000
		Incidentals and msc. items	4,000
	$118,780		$109,000

The above shows a conservative difference of $9780 in favor of the water system in cost of installation. The 20 per cent. in operating expense, amounting to $7800 for this particular building for fuel and water, if capitalized at 5 per cent., a large net income for most buildings of this class, would mean an equivalent reduction in investment of $156,000.

EDITORIALS

Giving the Central Station an Opening

In a large building in a Southern city, an isolated plant had been giving such poor service that the company seriously considered shutting it down and purchasing its current. A consulting engineer was called to thoroughly investigate the plant and make a report of its condition. The results obtained by the engineer showed an unusual lack of care and waste in the operation of the plant. It is small wonder that a change was contemplated, for the conditions existing would indicate that a cheaper rate could be obtained from the central station.

It goes without saying that a plant requires some engineering ability and care in its operation and, naturally, the equipment must be kept in good operating condition. Good results cannot be expected without this attention, and the engineer who allows a plant to deteriorate and get into poor condition only gives the central station an opportunity to oust him out of his job.

It appears that the boilers were in fair condition as to iron work, but the settings were leaky and required considerable attention. The firebrick in the furnace was burned out in a number of places and the stoker grates needed repairs, as a good deal of coal dropped through and large quantities of cold air rushed through the openings, reducing the efficiency of the boilers. The engines and dynamos were in good condition, but the feed-water heater was so small that a great deal of return hot water from the heating system was lost in the overflow.

In a twenty-four-hour test of the plant it was found that six pounds of coal was required to produce a horsepower-hour, or eight pounds per kilowatt-hour. This coal contained 13,566 B.t.u. per pound, 13.28 per cent. ash and 3.14 per cent. sulphur. It is not an enviable record, and much better results might have been obtained with the plant in good condition. The cost of the elevator service also proved to be excessive. Steam elevator pumps were used and a change to electrically driven pumps, using the same pressure tank, was recommended.

An adjacent building was supplied by the plant, with steam for heating. Upon investigation it was found that the heating system was wasteful and inefficient. In the first place, the pipe leading from the plant through the alley was entirely bare at a certain place, and the rain water falling on the pipe condensed a great deal of steam. The balance of the pipe was laid in an iron water pipe, with scarcely any air space between the two, and both pipes were inclosed in a trench cut in the rock. The waste of heat in this underground section of the supply main may be readily imagined. A one-pipe gravity return system was installed in the building, and this was not properly put up. Such a system should have the radiators set and the pipes connected so that the water can drain out along the bottom of the radiators and follow the pipe downhill to the return pipe, so that there will be no opportunity for pockets. Instead of this, numerous places were found where the steam feeder pipes tilted the wrong way, causing the water to stand in the pipes and necessitating the use of high-pressure steam. A method of properly draining the radiators was suggested so that it would be possible to heat the building with exhaust steam at not over three pounds pressure in the coldest weather, in place of live steam now used at twenty-nine pounds in the boiler room and reduced to nine pounds in the basement. Numerous other defects of minor importance were also pointed out.

With such conditions existing, it is small wonder that the management was dissatisfied with the results. Even with central-station current it would be necessary to remodel the heating system, repair the boiler settings and grates so that steam will be supplied efficiently for heating and substitute electric-driven pumps for the steam pumps now operating the elevators. But with all this done the plant would be in good condition and should be able to generate current cheaper than the central station could supply it. So, in either case there is but one remedy by which results may be bettered, and that is, put the plant in shape and keep it in the pink of condition.

❖

Working with the Specialist

The ever increasing cost of fuel accounts for the growing disposition of owners to subject their power plants to scientific examination to discover any possible way to increase efficiency and effect economy. The fact that the operating engineer himself has been able to make certain tests, compile figures from these tests and make some improvements, will not in many cases avert the inspection of the plant by the consulting engineer. Owners have come to feel about their power plants somewhat as a parent feels about a child who has been ailing for a long time—the family doctor may be treating the case rightly, but it is safer to have a specialist look the child over, even if he only confirms the regular physician's diagnosis.

So the plant owner is calling in the specialist, the consulting engineer, to make a scientific investigation of facts and conditions with a view to possible improvement. Very often his report simply confirms the operator's view, but whether it does or not it is as much an advantage to the operating engineer as to the owner and he would indeed be foolish who opposed any such examination. If the operating engineer is uptodate, he welcomes it because it will vindicate and strengthen him in his position if he has been doing things just right, or it will discover and remove any weak spots in his practice.

For this reason the operators ought to, and can well afford to, assume the most friendly and helpful attitude toward the consulting engineer whom the management has invited into his plant. The consulting engineer is not a rival, but a colleague with some superior advantages that help bring success in the effort to remove weaknesses in his plant and add strength and efficiency to it. The

operator who best serves his own interests, as well as those of his employer, will take the greatest possible advantage of this coöperation. He will cultivate the friendship of the consulting engineer, will take him into his confidence and put candidly before him any questions and problems in the plant operation which have puzzled him. It is his privilege to do this, for the consulting engineer's time and knowledge are paid for by the plant owner. He certainly should assist as much as possible in making any tests, and unless he understands these tests thoroughly he should not hesitate to ask questions. What he learns now may prevent his showing ignorance at a later and more critical time. Thus he may learn to judge of and advise upon the selection of competent specialists for the owner to engage to make subsequent examinations.

Meeting the outsider half-way will result in benefit to the operator and probably render the examination of his plant very much more successful than it could be without his cordial help.

Incidentally the indorsement which any fair-minded consulting engineer will give a competent operating engineer will have more influence with the employer than all the unsubstantiated arguments that the engineer could advance for a raise in salary. From all considerations, it appears not only the philosophical thing, but positively and practically the most advantageous thing to do, for all concerned, for the operating and consulting engineers to work with, not against, each other. Logically, their services are not competitive but complementary.

Concealing the News

Most people are interested in reading the news. It is almost a fundamental habit, in this country especially, acquired long before maturity is reached. Now here is the inconsistency—great as is our avidity to get the news we instinctively withhold such news as pertains to ourselves. Unless it is in connection with something to which honor attaches we have a horror of having our names in the papers.

This can be understood when one has committed a crime or done something scandalous, but why in the name of all that is reasonable does anyone deny information regarding a boiler explosion, flywheel disaster or anything of that kind?

We wish we might bring home very strongly to our readers the idea of coöperation in this matter of news so that they would not conceal news when it concerns their plants. If they would only regard it a duty they owe to their fellow engineers in return for the information they get of others, they would change their attitude toward the news seekers from the papers.

Some of our readers are accommodating and courteous when approached for news by our representatives. We are indeed grateful to them and even more so to those others who anticipate our desire for news and on their own initiative send items regarding their own plants or plants in their locality.

Regrettably there is this large class of conservatives who cannot bear to think of being "written up." If an accident has happened for which the engineer was responsible he naturally shrinks from publicity. Even then he should be broad gage enough to be willing that his mistake be made a warning to others. When the accident is one due to circumstances over which neither the engineer nor any of his assistants had any control it is foolish to imagine that an account of it in the papers will reflect any discredit on him.

We feel we have a stronger claim on such news than the daily papers because our motive in writing up accidents is that it may help other engineers avoid the same kind, if the cause has been discovered. There is no purpose of exploiting these things for the sake of notoriety or sensation.

POWER seeks to cover all reachable accidents that may contain a lesson or in any way add to the knowledge of other engineers to promote the safety of those engaged in the industry, as well as the public at large. Now let us have everybody's help.

Interrupted Service

The experience of those Staten Island industries which were dependent on the Richmond Light & Railway Co. for power and which were completely tied up for five days as a result of the recent boiler explosion, serves as a forceful answer to certain arguments of central-station adherents.

As far as the lighting is concerned, its absence was an inconvenience, but the residents have become so accustomed to interrupted service with every summer thunder storm that their attitude has changed from one of protest to mere tolerance. With the power customers the problem was far more serious, however, and those industries which possessed private plants were indeed fortunate.

The accident was most deplorable, whatever the contributing causes, and in spite of what appears to have been unnecessary delay in the resumption of service, the incident serves to point out the undesirability of "putting all the eggs in one basket."

Within the legitimate field of a public utility the community's interest is usually best served by a single company and seldom has cut-throat competition proved desirable. At the same time, in return for this monopoly, the citizens have the right to expect certain guarantees of service, one of which is sufficient reserve capacity, properly distributed, to guard against just such exigencies as the present.

The Loading of Boilers

For emphasis, we repeat what J. E. Terman has said on another page regarding the loading of boilers:

When horses are hitched together, the draft gear is usually arranged so that it will be necessary that all pull alike, but the average steam engineer will hitch from two to ten or more boilers together without apparently giving the matter much thought as to whether each will carry its proper share of the load or not.

And a little farther on:

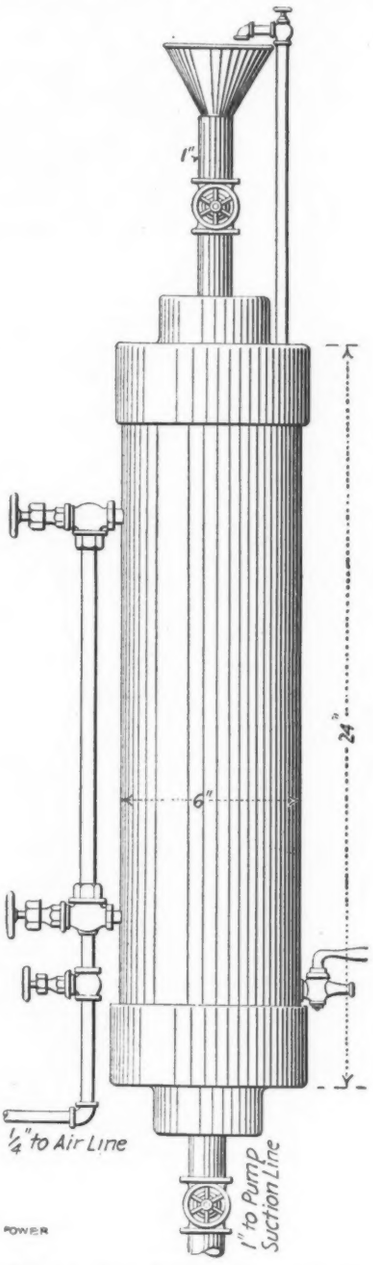
When two or more boilers are operated on a load that approximates their combined capacities, the efficiency will be maximum when the load is distributed between them in proportion to their capacities, and the efficiency will be less the greater the inequality in the distribution of the load.

Of course, most engineers know all this perfectly well. So do most small boys know that if they eat too many green apples they will have cramps, but they keep on eating green apples.

READERS WITH SOMETHING TO SAY

Another Compound Feeder Made of Pipe

We have in use a boiler-compound feeder consisting of a piece of 6-in. pipe 24 in. long, with a plug in each end. At the top there is a 1-in. nipple, a globe valve and funnel for filling, also a ¼-in. vent pipe to allow the escape of air when putting in the compound. At the bottom is a 1-in. pipe with a globe valve connected to the suction line of the boiler-feed pump. A drain cock is also provided. An ordinary water gage-glass is fitted to the side of the reservoir, and at the bottom of this glass is connected a ¼-in. pipe with a needle valve which is connected to a compressed-air line.



FEEDER FOR BOILER COMPOUNDS

To operate this feeder close the 1-in. valve in the suction line, also the needle valve in the air line, then open the valve between the funnel and reservoir; the ¼-in. vent is opened also, and in case the air comprsesor should not be running, any water left in the reservoir can be drawn off at the small drain cock at the bottom. If we have air pressure when filling, the air can be turned on and the water is quickly forced into the suction line of the pump, the compound, which is previously dissolved in water, is now poured into the reservoir. Both the valves at the top are closed and the valve in the suction line opened, then the needle valve is adjusted to feed the required amount of compound. Air bubbles rise in the glass and it is possible to accurately judge just how fast the compound is being fed to the boilers by observing these air bubbles.

S. A. STANDLEY.

Fort Wayne, Ind.

Strains in Flywheels

After reading the letter of John F. Hurst, on page 242 of the Aug. 12 issue, and also the letter of Forrest Allen, which preceded it, it appears that an explanation of a few of the simple calculations concerning the estimation of the force expended in producing changes of speed in flywheels, may be of interest.

Mr. Hurst's surmise that engine governors cannot be built to care for the sudden throwing off of all load is, of course, not correct. Thousands of street-railway engines are operating under conditions where a maximum overload is reduced to no load instantly, when the circuit-breakers come out. Such action is often repeated many times a day, and the governors on these engines take care of the speed fluctuations, and without producing any severe strains in the flywheel.

To calculate the energy stored in a rapidly revolving flywheel, it is simplest to consider what the stored energy would be if gravity had acted on the wheel for a sufficient length of time to produce the same conditions of speed as those for which the calculations are to be made. When a body falls from a height, the formula

$$v = gt \qquad (1)$$

expresses the relation between the velocity and time of falling, if we neglect the action of the air. In this formula, v is the velocity in feet per second, t the time of falling, in seconds and g is the acceleration due to the force of gravity, which is about 32.16 ft. per sec. at the sea level. The formula

$$v = \frac{2h}{t} \qquad (2)$$

expresses the relation between the velocity, time and height of fall. If the velocity is known, the time may be obtained by the use of the formula (1); and by using the

result in formula (2), the height of fall is found. It is evident that, if the weight of a body and the height through which it has fallen be known, the stored energy in foot-pounds may be obtained by multiplying the weight in pounds by the fall in feet. Bodies of equal weight and speed (which represents falls of equal height) have the same amount of energy stored in them, so that if we know these two factors for any case the stored energy can be calculated, this is so whether the body is moving in a straight line, as would be the case for a falling body, or a body revolving around a center, as the rim of a flywheel. Considering a practical case of a 500-hp. engine with a 20-ft. flywheel revolving at 80 r.p.m. and with a rim weighing 30,000 lb.; we find by figuring the speed of the rim, that it is running at 83.7 ft. per sec. The amount of energy stored in the rim, expressed in foot-pounds, would be (as explained above) the distance in feet through which it would have fallen to obtain this speed, multiplied by the weight of the rim in pounds.

Using the velocity of 83.7 ft. a second in formula (1), we have,

$$83.7 = 32.16\,t \text{ or } t = 2.6 \textit{ sec.}$$

Using the value of t just found, in formula (2), we have

$$83.7 = \frac{2\,h}{2.6} \text{ or } h = 109 \textit{ feet}$$

This indicates that in order to attain the same velocity by falling as when revolving, the rim of the flywheel would have to fall through a space of 109 ft., and it would therefore have stored in it

$$30{,}000 \times 109 = 3{,}270{,}000 \textit{ ft.-lb. of energy}$$

We, therefore, know that without considering friction or any other factors that may affect the result, that there must be put in the rim of this wheel 3,270,000 ft-lb. of energy, to bring it from a state of rest up to a speed of 83.7 ft. per sec.

Assuming that the engine cylinder delivers the same turning effort to the crankpin at all speeds, the average speed of the wheel starting from rest would be 40 r.p.m., or power is stored at the average rate of

$$\frac{500}{2} = 250 \textit{ hp.}$$

which is

$$250 \times 33{,}000 = 8{,}250{,}000 \textit{ ft.-lb. per min.}$$

and if there were no other work to be done the energy would be stored in the flywheel rim and would revolve the wheel faster and faster. Since it requires the storage of 3,270,000 ft.-lb. of energy to get the rim up to normal speed, it would take

$$\frac{2{,}270{,}000}{8{,}250{,}000} = 0.396 \textit{ min.} \text{ or } 23.8 \textit{ sec.}$$

to get this wheel up to normal speed with the throttle wide open and no load on the engine.

The friction of the air in the case of the falling body, and the friction of the air and bearings in the case at the flywheel have not been considered, nor have several other factors that would have a bearing on the actual time it might require to bring a wheel up to speed been considered, but the main retarding influence in most engines is the weight in the flywheel rim and the above calculations show how the amount of this effect can be estimated. It can be readily seen that to start or stop a wheel suddenly means the expenditure of an immense amount of energy, and Mr. Hurst's idea that the speed may become dangerous in a portion of a revolution, is, of course, not correct for wheels ordinarily used on engines. For example, take the case of the wheel just considered and assume that the speed is to be increased 2 per cent. above normal. It would be necessary to store about 133,000 ft.-lb. of energy in the rim to accomplish this change in speed and this would take about $^{65}/_{100}$ of a revolution, if we assume that the entire energy developed by the engine was devoted to speeding up the rim. A 2 per cent. or even a 20 per cent. increase in speed could not be considered dangerous if the normal speed of the wheel was one that could be considered safe. The factor of safety under which flywheels usually operate, is such, that a speed of at least three times the normal speed is required to burst them. Taking the wheel that we have considered above, and assuming that a rim speed of 15,078 ft. per min. would burst it, we find by making the calculations as previously explained, that there would be required stored about 26,200,000 ft.-lb. of energy, or 126 revolutions, at an average speed of 160 r.p.m., to reach the bursting point, or it would require 47 sec. after all the load were thrown off before the wheel would reach the bursting speed. With a fairly good governor no severe strains are likely to be produced in the flywheel by suddenly throwing off load, but the strains that may be produced by suddenly throwing on a heavy load can hardly be estimated. Where the shock is not transmitted directly to the rim of the wheel, as would be the case with water in the cylinder or with a direct-connected engine and generator when a short-circuit occurs, the strains on the flywheel are extremely severe. When water gets in the cylinder, there is usually some portion of the engine frame or wheel broken, as the force expended in these cases depends on the time in which the stored energy in the wheel and other parts of the engine in motion must be cared for.

J. E. Terman.

Hartford, Conn.

❖

Collecting and Reusing Cylinder Oil

The question of reusing cylinder oil seems to deserve little consideration, judging from what little has been said about it. However, we have worked out an idea by which we have effected a 30 per cent. saving in the oil consumption. Since the apparatus is inexpensive a description of it may be interesting.

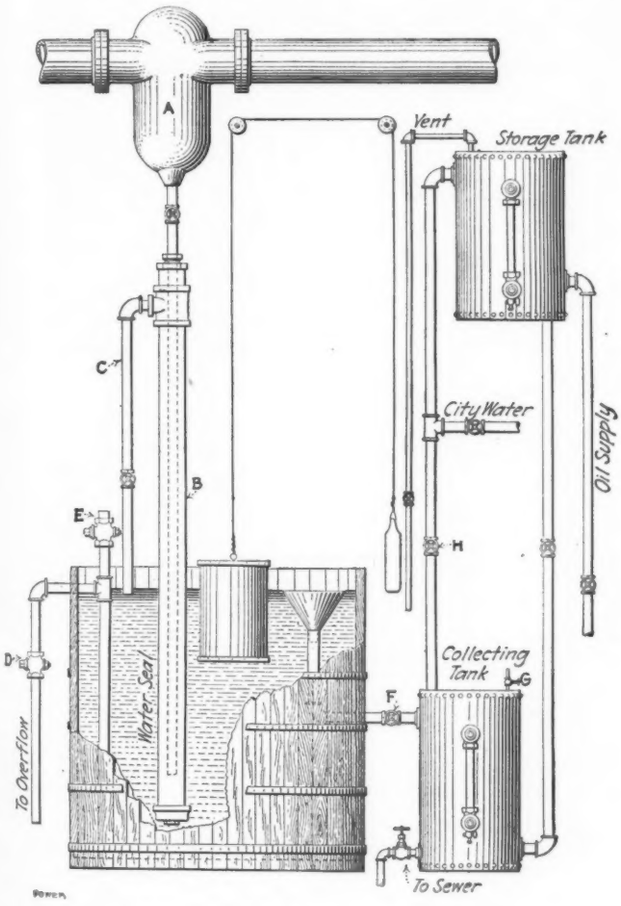
A series of experiments disclosed the following facts: First, that the viscosity of cylinder oil after passing through highly heated spaces, such as steam-engine cylinders, is greatly impaired; that having been gathered with a mixture of steam and water, it is more or less emulsified and will not work in ordinary drop-feed lubricators. It is, however, worth saving for use in pumps, etc.

The illustration shows clearly how the oil is collected and separated in our plant. No attempt has been made to use this oil on a higher class of machinery than direct-acting pumps of moderate speed.

From the oil separator A in the main exhaust line, the mixture of oil and condensate enters first a water seal B made up of 1-in. pipe inserted in a 3-in. pipe, the former open at the lower end. The mixture must rise to another 1-in. discharge pipe C, the top of which is but a short distance below the separator. The oil and water are dis-

charged through pipe *C* into a large open tank in which the oil rises to the top. A skimmer in the form of a funnel is placed in this tank in such a position that the slight rise in the oil level in the tank will cause the oil to flow into the funnel and then to a collecting tank. The surface of the liquid is raised by means of a bulky weight or displacer being lowered into the liquid. The cock *D* in the water drain pipe must be closed when the displacer is lowered into the tank.

To run the tank empty it is necessary only to lower the displacer enough to start the water through the overflow with the cock *E* closed when a siphon will be formed. When the collecting tank is full the inlet valve *F* and



Apparatus for Reclaiming Cylinder Oil

the vent valve *G* are closed and the valve *H* in the 1-in. line to the storage tank is opened. This tank corresponds in size with the one on the floor, but it is located well above the rest of the apparatus and has a return connection to the floor tank so as to allow a more rapid elevation of the oil as it leaves the top of the bottom tank to enter the top of the top tank.

The water runs from the bottom of the top tank to the bottom of the bottom tank. When the oil is all up, the water is run from the collecting tank into the sewer to make room for more oil.

The oil is fed to the pumps by gravity droppers. A larger quantity of this oil must be fed than if first-class oil were used.

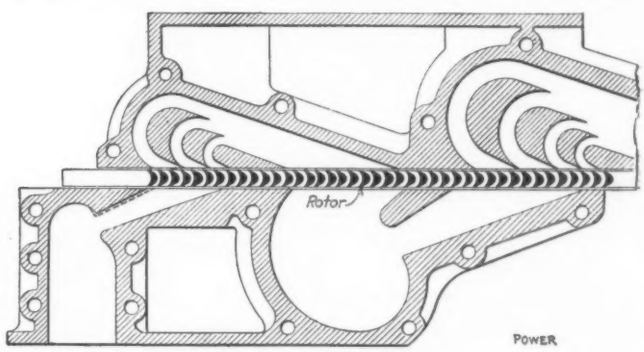
Edward T. Binns.

Philadelphia, Penn.

Turbine Nozzle Too Small

Much trouble was caused through a low-pressure turbine not giving its rated output. With steam at 15 lb. per sq.in. abs., it was supposed to give 300 kw., but we could not get more than this with a pressure of 18 lb. abs. The pump was running at 1480 r.p.m., which was 20 less than called for. The rotor of the turbine was lifted out and all the blades cleaned, and where any were a little "out" they were set back to their original position. But this made no improvement in the running of the turbine.

At last two holes were tapped in the steam line; one of these holes was on each side of the governor which stepped down the pressure for use in the turbine. The gages indicated equal pressures, showing that the governor was admitting steam but that the steam was held in the first nozzle of the turbine. The nozzle was lifted out and made larger, as shown in the illustration; the dotted line showing the original size of the nozzle. We turned down one side of the nozzle to a 20-deg. angle



Partial Section of Turbine

of entry and planed about $\frac{1}{16}$ in. off the opposite side. When the turbine was assembled and steam admitted, it ran 1580 r.p.m. under full load. On applying the load to the turbine we were able to get 400 kw. with an initial pressure of 18 lb. abs. and could easily carry all the load required.

James A. Campbell.

Lowell, Mass.

❖

Power-Plant Vibration

In the article on "Power-Plant Vibration and Methods of Isolation," by Francis H. Davies, in the Aug. 12 issue, the figures regarding minimum and maximum thicknesses of $\frac{1}{8}$ to $4\frac{3}{4}$ in. for cork-isolated plates and also the compression tests given apply to our material "Resilient" plate. This is largely used by the principal underground railways in place of felt and such like material, as pads for rail chairs and railway carriages, and also in building construction, machinery foundations, etc. This is the material, which has been tested to a pressure of 2500 lb. per sq.in. with successful results.

The iron-framed cork foundation plate described by Mr. Davies is called "Bavanite" and is made in a standard thickness of $2\frac{3}{8}$ in. A copy of tests for resilence carried out on these plates is given herewith.

In these tests it will be noticed that the maximum pressure was 210 lb. per sq.in. with a mean compression of 45.9 per cent. of the thickness, returning 5 min. after

the removal of the load to a residual compression of 11.43 per cent. In actual practice we allow a maximum working pressure of 20 lb. per sq.in., and, generally speaking, it is found that the average pressures on the base of con-

COMPRESSION TESTS FOR RESILIENCE OF "BAVANITE"

Test Piece No.	Mean dimensions before test, in. Thickness, in	Breadth in.	L'gth in.	Area	Total compression per cent. under following loads. Lb. per sq.in. 35	75	105	140	175	210
1.	2.375	7.875	7.875	61.75	....	8.5	25.5	38.2	44.0	45.5
2.	2.375	7.875	7.875	61.75	4.5	7.8	23.5	38.5	43.3	44.5
3.	2.375	7.875	7.875	61.75	1.7	6.8	26.5	39.7	44.7	48.7
Mean	2.375	7.875	7.875	61.75	2.06	7.7	25.16	38.8	44.0	45.9

Residual deformation per cent. after removal of following loads in lb. per sq.in.

	105		140		175		210	
	At once	5 min. after	At once	5 min. after	At once	5 min. after	At once	5 min. after
1.	7.5	5.0	15.7	8.8	19.3	11.7	21.7	13.3
2.	8.8	4.3	14.0	8.5	18.7	10.8	18.7	12.5
3.	7.3	3.0	12.3	5.8	14.3	7.7	18.0	8.5
Mean	7.86	4.1	14.0	7.7	14.1	10.6	19.46	11.43

The Royal Engineering Institute, Charlottenburg, 1912.

crete foundations rarely exceed 15 lb. per sq.in., thus leaving a factor of safety in the working of the material.

ROBERT B. GREY, Gen. Mgr.,
The British Anti-Vibration & Noise Co., Ltd.
London, Eng.

Analysis of Mr. Chandler's Diagram

It looks to me as though W. E. Chandler has a wrong idea of which is the expansion line in the left-hand diagram of the indicator diagram shown in the Sept. 16 issue. The expansion line of this diagram is the lower line where one generally finds the exhaust line.

When the piston moves forward with the steam valve closed there is but little steam in that end of the cylinder in which steam was trapped by the exhaust valve when it closed. This steam soon expands so much that a vacuum is created in this end of the cylinder. There is 11 lb. steam pressure in the receiver, and when the pressure in the cylinder drops low enough this 11 lb. acting on the area of the exhaust valve covering the exhaust ports overbalances the pressure in the cylinder acting on the top of the valve and also the weight of the valve. The valve will lift, letting a little steam into the cylinder from the receiver. This causes the expansion to be nearly straight for a good part of the stroke near the end, as the piston is traveling slower, enough steam leaks in to raise it a very small amount.

When the exhaust valve opens, the steam from the receiver rushes in and raises the pressure in the cylinder. This engine is a tandem compound, and when the exhaust valve closes the engine begins the return stroke, and the low-pressure cylinder is taking steam from the receiver. This causes the pressure in the receiver to fall slightly until the steam valve on the low-pressure cylinder closes, when the line on the diagram is nearly straight. Now, when the exhaust valve closes, the steam that is in the cylinder is compressed, as shown in the diagram. When the engine next starts on the forward stroke this steam expands, but, due to condensing and leakage, the pressure does not follow the compression line but falls below it.

The exhaust valve on the head end closes a little ahead of the exhaust valve on the crank end.

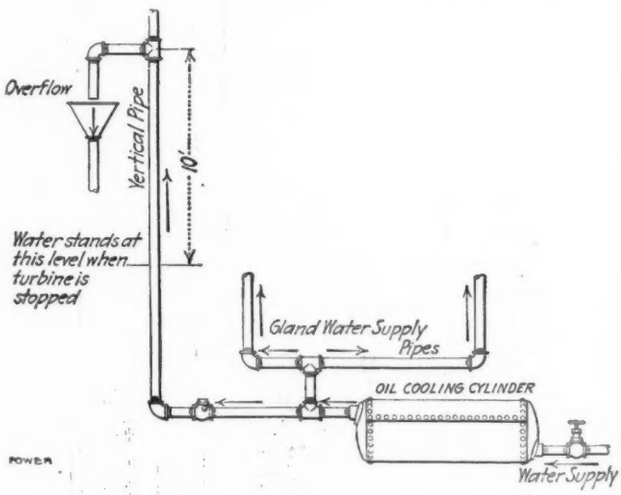
L. A. FITTS.
Greenfield, Mass.

Sealing Glands of Low-Pressure Turbines

In that class of low-pressure turbine which uses water seals to prevent air leaking in where the shaft comes through the case the sealing does not become effective until the turbine has attained considerable speed. As the turbine will not start until there is a vacuum in the condenser, these turbines require auxiliary glands to seal the shaft opening while the vacuum is being built up in the condenser by the air pump or ejector.

There is in the plant of which the writer has charge a turbine of this type which was piped for gland-water supply according to the builders' suggestions, as shown in the sketch. From the start we had considerable trouble getting a vacuum created in the jet condenser; the vacuum would build up momentarily to about 12 in., and then drop back to zero.

A study of the piping will show that as soon as the small amount of water remaining in the standpipe was drawn into the turbine by the vacuum, the standpipe would be fully open to admit air into the turbine and prevent the vacuum being built up. As the auxiliary



PIPING ARRANGEMENT FOR SEALING GLANDS OF TURBINE

glands are outside the centrifugal glands they cannot prevent the inflow of air through the gland water-supply pipes.

A swing check valve *A* placed in the horizontal pipe leading to the 10-ft. riser will prevent this trouble and facilitate starting in installations having no forced injection line or valve between the turbine and condenser.

Turning on the gland-water supply will also prevent the entrance of air, but is not very desirable because the water flows into the turbine at each end, until the speed is high enough to seal the glands. The cool water flowing over the heated shaft together with the danger of getting water into the oiling system are the objectionable features of this method.

P. L. WERNER.
McKeesport, Penn.

[The sealing glands of condensing turbines should also be carefully watched for scale. Where the sealing water is alkaline and is heated by the shaft, scale will sometimes form.—EDITOR.]

INQUIRIES OF GENERAL INTEREST

Cleaning Grease from Boilers—How may boilers be cleaned of grease deposited in them where surface condensers are used?

N. N.

Coatings of grease can be removed from boilers by using a solution of soda ash and water boiled up in the proportion of about 1 lb. per 10 hp., after which the boiler should be blown off and washed out.

Locating Water Coolers—Is it important to put atmospheric distilled-water-cooling coils, as well as ammonia condensers, for a refrigerating plant, where air or wind can strike them, or might they be put inside of a tower with 12 to 18 in. headroom and only two small windows opening to the outside air, both on the same side of the room?

R. H. R.

Wherever possible, both the open-air condensers and the open-air distilled-water coolers should be placed where the outer air can circulate around them freely. Care should be taken, however, to shade them from the direct rays of the sun. It would not be considered good practice to put this apparatus inside of a tower, such as described, for the air in this tower would very soon become practically saturated with moisture and no benefit would be derived from evaporation.

Safe Flywheel Speed—We have an engine running at 74 r.p.m. with a flywheel 12 ft. in diameter with a 21-in. face and rim 2½ in. thick, cast in two sections. How much faster can the engine be run safely?

J. C. M.

The maximum safe speed for sound cast-iron flywheels is usually taken to be a rim speed of a mile a minute, i.e., 5280 ft. per min. If the wheel is made up in halves or other sections, the lugs, bolts and other fastenings are supposed to be made as strong as the rest of the rim. The breadth and thickness of the rim are immaterial, as the centrifugal force is directly proportional to the weight, and the strength is directly proportional to the size. The wheel being 12 ft. in diameter, its circumference is $12 \times 3.1416 = 37.69$ ft., and with fastenings of sections equal in strength to the rim and the casting sound, the wheel should be safe at a speed of

$$\frac{5280}{37.69} = \text{about } 140 \text{ r.p.m.}$$

Flow of Water—Can the formulas given in the article in the July 1, 1913, issue "Flow of Water in Pipes," be applied to pipes having a diameter of 100 in., and a loss of head of 100 ft. per 100 ft. of pipe?

J. P. Z.

Durand's formulas and chart apply to flow of water in iron pipes up to 12 in. diameter discharging with loss of head up to 10 ft. His article is based on the average of different formulas for the loss of head, etc., in the commercial sizes of iron pipe as quoted by Mr. Evans, July 9, 1912, issue, referring to losses in sizes used in hot-water heating. It is hardly probable that the formula which you refer to would hold true as an average extended to pipes 100 in. in diameter especially as the Chezy and other formulas referred to require the use of a constant determined by experiment for each particular case. On comparing actual tests of large pipes (i.e., 36 in. to 100 in. diameter) Darcy's formula has been found to come closer to the average than any for the use of which constants are not established for the case in hand. But no set formula, i.e., one for which constants have not been established for the particular case in hand, can be relied on closer than about 15 per cent. on account of the difference in roughness of pipe surfaces.

Nozzle Discharge Velocity—What would be the velocity of the water discharged through a 1-in. nozzle under a pressure of 75 lb. per sq.in.?

C. A. G.

A pressure of 75 lb. would be equal to a head of $75 \times 2.309 = 173.17$ ft.

The theoretical velocity of discharge in feet per second would be

$$v = \sqrt{64.32 \times 173.17} = 105.5 \text{ ft. per sec.}$$

The average velocity of discharge from a nozzle, taken at the smallest cross-sectional area of the issuing solid stream, i.e., at a few inches beyond the nozzle, would be 95 to 97 per cent. of the theoretical velocity, depending on the smoothness of the nozzles.

(For a "ring" nozzle, the smallest part of the stream becomes reduced to about 65 per cent. of the cross-sectional area of the nozzle, and for a nozzle with a gradual taper and smooth bore, the cross-sectional area will be practically the same as the nozzle.)

A 1-in. nozzle would have a cross-sectional area of 0.7854 sq.in., and a smooth bore nozzle under 75 lb. pressure per sq.in. at the nozzle should discharge

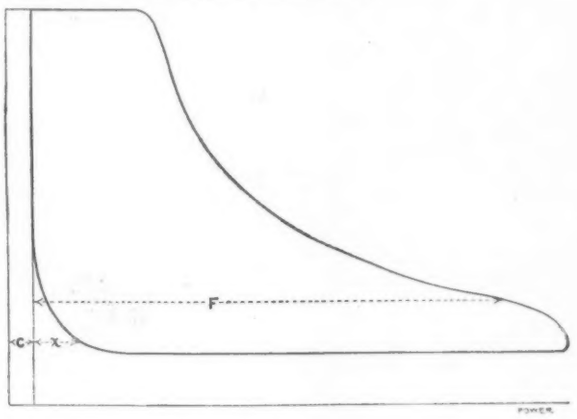
$$105.5 \times 95 \text{ per cent.} \times \frac{0.7854}{144} \times 7.5 \times 60 = 245.98 \text{ gal.}$$

or practically 246 gal. per min. With a 1-in. dia. "ring" nozzle, the discharge should be 65 per cent. as much, viz.: 65 per cent. of 246 = 159.9 gal., about 160 gal. per min., or 62 per cent. of the theoretical discharge.

Steam Consumption—How is the steam consumption of a compound engine calculated from indicator diagrams?

J. A. P.

The same formula is used as for a simple engine and will be understood by reference to the following diagram taken from Low's "Steam Engine Indicator":



$$Q = \frac{13{,}750}{p}\left[(F + c)\, w_f - (x + c)\, w_x\right]$$

in which

- Q = Pounds accounted for per horsepower per hour;
- p = Mean effective pressure, pounds per square inch;
- c = Clearance in fraction of stroke;
- F = Fraction of stroke completed at some point chosen on the expansion line;
- w_f = Weight per cubic foot of steam at a pressure corresponding to the point chosen on the expansion line;
- x = Fraction of stroke uncompleted at some point chosen on the compression line;
- w_x = Weight per cubic foot of steam at the pressure corresponding to the point chosen on the compression line.

A diagram from either cylinder may be used, but the mean effective pressure employed in the formula must be one which would give the equivalent total power if it existed in the cylinder from which the measured diagram was taken. For example, if a low-pressure cylinder diagram is used, to the mean effective pressure for that cylinder must be added the mean effective pressure in the high-pressure cylinder multiplied by the square of its diameter and divided by the square of the low-pressure cylinder diameter. If a high-pressure diagram is used, the low-pressure cylinder mean effective pressure multiplied by its diameter squared and divided by the high-pressure cylinder diameter squared, must be added to the high-pressure cylinder mean effective pressure. In other words, the mean effective pressure in one cylinder corrected for combination with that in the other cylinder is inversely proportional to the squares of the diameters of the respective cylinders. If the strokes in the two cylinders are not equal, which is very rare, correction for that fact would have to be made.

ENGINEERS' STUDY COURSE

Feed-Water Treatment—III

To secure desirable results in treating feed water the quantity of compound supplied must be proportioned according to the amount of scale-forming impurities present. To estimate the amount of impurities present necessitates an analysis of the water. Generally speaking, a water analysis can only be made by a trained chemist. It can be attempted by others, but the results obtained would in most cases be so inaccurate as to be useless. The engineer can, however, make an approximate analysis which is of some value in indicating the character of the water and if the analysis is made with care and the water does not contain impurities that complicate its nature too much, the kind and quantity of scale-preventing compound needed can be estimated.

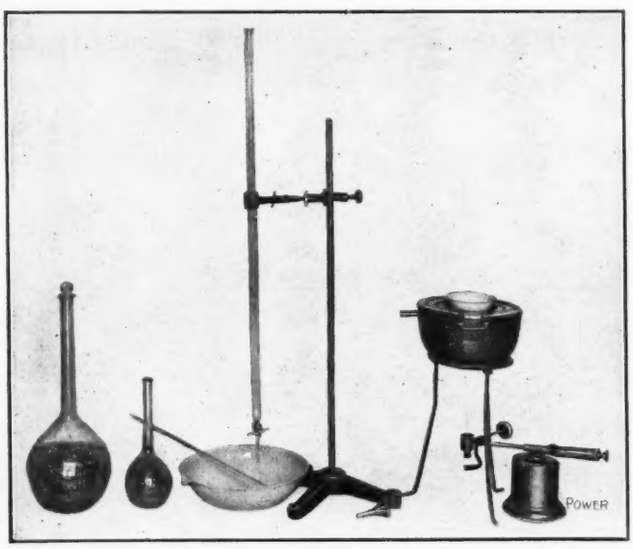


FIG. 1. APPARATUS REQUIRED FOR PROXIMATE WATER ANALYSIS

The following method of approximate water analysis is based on that given by John B. C. Kershaw, in "Fuel, Water and Gas Analysis," published by D. Van Nostrand Co.

TEST APPARATUS

Assuming that the reader possesses the apparatus for making the proximate fuel analysis, as listed in the May 27 lesson, the following additional equipment, most of which is shown in Fig. 1, is required for making the proximate water analysis as here outlined:

1 Copper water bath, 6 in. diam	$1.50
1 Measuring flask (200 c.c. capacity)	0.35
1 Porcelain dish (22 oz. capacity)	1.00
1 Glass stirring rod	0.10
1 Burette, graduated in $\frac{1}{10}$ c.c. (50 c.c. capacity)	2.00
1 Funnel for filling burette	0.10
1 Support or stand for burette (adjustable)	0.80
1 Measuring flask (100 c.c. capacity)	0.90
1 Porcelain dish (about 50 c.c. capacity)	0.15
1 Glass funnel for filtering (4-in.)	0.20
1 Package of filter paper (8-in., 100 sheets)	0.35
	$7.45

The following chemical solutions are also required:

2 oz. concentrated solution methyl orange	$0.50
1 liter—one-fifth normal standardized solution hydrochloric acid	1.40
1 liter—one-fifth normal standardized solution sodium carbonate	1.40
2 oz. alcoholic solution phenol-phthalein	0.50
	$3.80

If the reader does not possess proximate fuel-analysis apparatus it will also be necessary to secure a bunsen burner or an alcohol or gasoline lamp (such as is shown in Fig. 1) and an iron tripod or adjustable iron stand for supporting the water bath.

COPPER WATER BATH

The copper water bath, shown on the tripod in Fig. 1, is employed when evaporating a sample of water under conditions requiring a uniform heat at 212 deg. F. The bath is fitted with a lid composed of rings of various diameters so that the vessel containing the sample may be conveniently supported over the boiling water. A vent or spout at the side and just below the top permits the steam to escape without inconvenience to the analyst.

MEASURING FLASK

As the name implies, a measuring flask is used to measure out samples or reagents when accuracy is important. Its neck is small in diameter, and has a fine line around it to which level the liquid to be measured is poured.

BURETTE

The name burette should be familiar to the reader, as we employed one in measuring flue gas when making an analysis with the Orsat apparatus. As may have been surmised, "burette" means measuring vessel. In the present case the burette is employed to measure liquids.

Acids neutralize alkalies and *vice versa*. For instance, water containing a quantity of some acid has certain definite characteristics whereby its acid nature can be recognized. It will corrode or eat away certain metals, say, iron, and it will, generally, change a sensitized paper called litmus paper from blue to red. Now, if a certain definite quantity of alkali is added to this water the latter will lose its acid characteristics—because the alkali has neutralized the acid it contained by a chemical action between them. If more alkali be added so that the water now contains a quantity in excess of that which was required to neutralize the acid, other characteristics will be acquired. A definite quantity of alkali is required to neutralize a given quantity of acid and *vice versa*. For illustration, if a gallon of water contained, say, an ounce of a given acid, hydrochloric, for instance, it would be found that a definite amount of some alkali, say, sodium hydrate, would be required to neutralize this acid.

When the amount of contained acid is known, the amount of the required alkali can be calculated. Hence, when the amount of the acid is unknown, but by experiment the required amount of alkali is ascertained, it is possible to calculate therefrom the quantity of acid neutralized.

This principle is extensively made use of in chemistry. When analyzing water certain chemicals are added to the sample being analyzed and the amount of such chemicals required to produce a certain change is measured as accurately as possible. This is the purpose of the burette; it is made long and of small diameter so that the quantity of liquid contained before and after some has been let out can be measured closely. When a person adds chemicals to a sample by means of the burette and measures the quantity required to produce a certain change in the character of the sample, for the purpose of estimating its original make-up, he is said to titrate the sample. If it is sodium hydrate he happens to be adding he is said to be titrating with sodium hydrate.

When emptying the burette of one compound and filling with another, first rinse the burette with distilled water and then pour in or rinse with a little of the new compound to be used and drain this out again before the main bulk of the new compound is filled in.

Indicators

When titrating a sample of water with a certain chemical it is often necessary or convenient to first put some other compound into the water for the purpose of indicating by change in color when the point of neutralization has been reached. When a compound is employed for this purpose it is called an indicator. Methyl orange and phenol-phthalein are used as indicators when titrating with hydrochloric acid or sodium-carbonate solutions to ascertain alkalinity or acidity.

Hydrochloric Acid Solution, Etc.

The accuracy of results when titrating depends upon the accuracy in measuring the sample, the accuracy in preparing the titrating fluid, the accuracy in reading the amount of titrating solution required and the accuracy in determining the point when neutralization has been effected. As it is important to get the strength of the titrating fluids as nearly correct as possible it is recommended that the one-fifth normal standardized solution of hydrochloric acid and of sodium carbonate be purchased ready made up. This will save bother and trouble and insure a greater accuracy than can be obtained under average conditions where proper facilities for best work are not present.

The bottles containing the solutions should always be kept well stoppered so that the strength will not change due to evaporation.

⁂

What is Probably the Oldest Vessel to be fitted with an internal-combustion motor has just carried out her "maiden voyage under power." She is the "Ceres," built at Salcombe in 1811, and for many years was in the fruit trade in the Western Islands. In 1855 she was purchased by Messrs. Petherick, of Bude, who have just had her installed with a two-cylinder 24-hp. marine heavy-oil engine.—"The Gas Engine."

⁂

Situation for Elevator Inspector—The Chicago Civil Service Commission will hold an examination Nov. 4, 1913, for elevator inspector. Salary, $1440-$1620. Subjects of examination: Special subject, penmanship, arithmetic, experience, report. Duties: Inspects all elevators and other mechanisms, devices and apparatus assigned to him by the inspector in charge, both existing and in process of being erected or installed, together with all the equipment and inclosures thereof, making daily reports to the Commissioner of Buildings regarding condition of same; performs such other duties as may be assigned to him by the Commissioner of Buildings.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

It's been some lively in York village this week, what with Emmy Pankhurst and Tony Comstock, Old Bill Sulzer and Eddie McCall, Jawn Hennessy, Chief Murphy and other prominent villagers. There's some doin's expected come this day week.

⁂

We are hiding a coal supply away from our friends the enemy in chambers built in the bottom of the Panama Canal. Nobody's going to make an unexpected call on your Uncle Sam and find his fires out.

⁂

Relatives and friends, and others, have unveiled a statue to the Pilgrim Fathers in Southampton, England. While most of us never get any nearer a Plymouth Rock than the henyard, it's consoling to know that those jolly old roosters are still remembered in old Albion.

⁂

Some corn was raised in Illinois this year that was 17 ft. 2 in. high and produced 40 ears to the stalk. Hope this fact will bring down the price of Peoria "lubricant."

⁂

A frequent application of the garden hose keeps the English public statues real clean and perked up. Good plan to try hereabouts. Shakespeare's chin whiskers, Pete Stuyvesant's peg leg, George Washington's horse, Horace Greeley's lambrequins and a host of statuesque figures would be almost recognizable at times if old Dad Knickerbocker would buy a hose.

⁂

Doctor Diesel's death will be felt here as well as abroad, opines the "Engineering Record." "Imbued with the ambition of discovering a prime mover of high thermal efficiency, he always kept his attention steadfastly directed toward this great idea. He had a single great idea—and he clung to it."

⁂

Seven thousand men are at work building New York City's subway lines. The cost will be about $200,000,000. Soon there'll be 6,000,000 of us in Greater New York, and if we can't plow our way across the city, we must burrow under it

⁂

In a physicist's laboratory was discovered a spark phenomenon which in time grew to a worldwide usefulness—the wireless means of communication. As an instance, the other day it saved the lives of over 500 people on board the ill-fated "Volturno." Its usefulness is only beginning; no one knows its future power for good.

⁂

Ever seen a scarecrow—we mean a cornfield scarecrow? The Department of Agriculture has put the kibosh on the scarecrow by saying that the crow is a blessing, not a pest. And proved it on opening a crow's tummy and finding it full of detrimental bugs and insects—detrimental to the crops, that is. Seems like all our old institutions are fast disappearing.

⁂

If you know an A-1 "garbager" set him hep to Chicago. Some of the technical papers now carry a regular department heading: "Chicago's Garbage-Disposal Situation." "That city had two years to provide for handling the garbage, and has fallen down," says a contemporary. Let's see, two-year-old garbage, and it fell down? Must mean knocked down.

⁂

Now that the airship becomes a greater menace in wartime than a tunnel across the English Channel, the tunnel is being seriously considered. Perhaps, some near day, J. Bull and Jacques Bonhomme may be able to toddle over to see each other without their goloshes.

⁂

My word! but the "Electrical Times," London, for a technical journal is the giddy old thing. You'd jolly well believe it, old chap, if you'd read its account of the English National Gas Exhibition. It was ghastly! (Good joke, by Jove, eh what?) It blushed over the corset shop, it drooled over the "captivating young damsels," and it bloomin' near blew out the gas, because it doesn't like gas, y'know. I say 'Arriet, come 'ome with your 'Enry; this is no place for we.

A Practical Talk on Case-Hardening

By Frank Nicholson

SYNOPSIS—Case-hardening is usually a matter of guess work. Suggestions for obtaining uniform results are herein given. The article will prove of value to engineers who usually have a goodly share of case-hardening to do.

Case-hardening is accomplished by taking advantage of the fact that iron and soft steel combine with carbon at temperatures above a low red heat.

Case-Hardening Operations

The essentials in case-hardening operations are as follows: A suitable steel; the necessary furnaces and equipment; the carbonizing material; proper temperature.

The steel should be of good quality and uniform composition. A steel having the following analysis and mechanical properties is recommended:

Carbon not over 0.2 per cent. Manganese not over 0.5 per cent.
Sulphur not over 0.04 per cent. Maximum stress, 62,000 to 72,000 lb. per sq.in.
Phosphorus not over 0.04 per cent. Elongation in 2 in., 25 per cent.
Silicon not over 0.05 per cent. Reduction of area 55 to 60 per cent.

This steel will be found to give the necessary mechanical properties when properly treated. It should be free from all mechanical defects, such as seams, rolling laps, rolled-in scale, etc., and should preferably be annealed before machining. This treatment will release all molecular stress set up in the rolling operation.

The furnaces may be heated by coal, coke or gas. It is essential that the furnace should be capable of maintaining a uniform temperature. It is necessary that the furnaces should be equipped with pyrometers, so that the temperature can be regulated with precision and confidence.

Thermo-electric pyrometers are the handiest for most work, and they are easily manipulated. Care should be taken that the hot end of the thermocouple tube is placed in such a position that it accurately indicates the temperature of the furnace. Near the furnace should be placed the quenching tanks, so that the work on reheating may be quickly withdrawn and quenched. They should be supplied with clear cold water, which should be frequently changed.

Carbonizing Material

As already pointed out, the carbonizing is effected by carbon and some of its compounds, while the metal is at a red heat. Many mixtures have been used which will yield these necessary gases, including leather, charcoal, bone and bone charcoal, prussiate of potash, cyanide of potash and a mixture of charcoal and barium carbonate. The latter is recommended, the others being open to many objections. The proportions are 60 per cent. charcoal and 40 per cent. barium carbonate.

Assume that we have a batch of work to be carbonized. The boxes to contain the articles should preferably be of wrought iron, as this will stand much more fire than steel. For small work weighing only a few ounces to a few pounds, boxes 12x8x8 in. will be quite large enough.

*Excerpts from an article in the "American Machinist."

The packing should be carefully done. The bottom of the box should have a layer of carbonizing material about 1½ in. deep. The articles should be laid on this in such a manner that there is at least a space of 1 in. between each, and between them and the sides of the box. Another layer of material should then be laid on and the packing continued until the top layer is 1 in. from the top of the box. The material must not be rammed tight around the work, as carbonizing is chiefly effected by gases; sufficient space must, therefore, be left for free circulation.

If the materials and work are simply laid in and the boxes given several sharp blows with the hammer, the packing will evenly adjust itself. A test bar as nearly like the job as possible should be included in each box. The lid should now be dropped into position, so that it easily fits inside the top of the box. It should be luted on with wet clay, so that the gases generated may be retained to do their work and to prevent oxidation of the articles by the oxidizing gases in the furnace.

Carbonizing

With the furnace raised to a full red heat, the boxes are ready for charging. They should be put into the furnace in such a way that there is ample space between the sides of the furnace and the boxes and also between the boxes themselves. This will insure uniform heating and consequently better work. The boxes should be at a full red heat in from 1 to 2 hr., depending upon their number and size. The pyrometer should be inserted and the furnace regulated so that a temperature of 900 deg. C. is obtained. This should be maintained and not be allowed to exceed 925 deg. C.

In carbonizing, we are aiming to produce a case containing 0.8 to 0.85 per cent. carbon. This percentage will give us the necessary hardness without brittleness. If the temperature is raised too high the case will contain too great a carbon percentage, the articles will be likely to chip and flake; while if the temperature is not sufficiently high the article will not be hard enough.

An exposure of 3 hr. at a temperature of 900 deg. C. will yield a case of about $\frac{1}{32}$ in., and an exposure of 4 to 4½ hr. about $\frac{1}{16}$ in., which is ample for most purposes. When the operation of carbonizing is complete, the boxes should be withdrawn and allowed to cool slowly in the air. On no account must they be hardened in the good old hit-or-miss style by pitching into water.

If the test bar is now fractured it will be found to possess a coarse, granular fracture, which is said to "stare." The metal is in a very soft, weak and brittle condition and totally unfit for the purpose for which it is intended. This condition is caused by its exposure for a prolonged period at a high temperature. We see two distinct metals in the fracture, the case being much smaller in grain than the core. It is our business now to restore both the core and case to their greatest strength by suitably treating them.

Heat Treatment

Steel can be hardened by quenching from just above a certain critical point, which varies according to the

percentage of carbon contained in the steel. If a sample of steel is quenched from a temperature inferior to its critical point, the change which should take place at that point does not occur and the metal is not fully refined or hardened. If it is reheated to a temperature superior to this point and is then quickly cooled, it assumes the finest structure that it is capable of assuming, and, with that, its greatest strength.

The temperature at which this change is effected in the core is about 875 deg. C. The case-hardened articles should be reheated to this temperature and the heat should be fairly quick. A prolonged soaking will result in the growth of the crystals, and if this occurs the metal will be brittle. When the heat has been reached and the articles are properly soaked through, they should be quickly withdrawn and immediately quenched in cold, clean water.

This treatment, although it has made the soft core strong and tough, has rendered the case very brittle, because its refining temperature has been much exceeded. The articles should now be reheated to a temperature of from 770 deg. to 790 deg. C., and quenched as before. This treatment will produce a case which is deadhard, but which will leave the core unaffected. The reason for this is that the second temperature has not been sufficiently high to undo the effects of the higher temperature.

A heavy case will fracture long before the core, but it forms a line of weakness which will result in the fracture of the whole.

Many jobs may be greatly improved by tempering. Where great strength and toughness are desirable, even at the expense of a little surface hardness, the articles should be immersed for 10 or 15 min. in a bath of oil or tallow, heated to a temperature from 200 to 300 deg. C., according to the degree of temper desired.

A Combined Open Feed-Water Heater and Hot-Water Meter

It is hard for one to know how much better he might do if he does not know how well he is doing. It is hard to tell how much better one coal or one method of using it is than another if one has no way of measuring results.

There is nothing that can be put into a steam plant which will give the operator more valuable information, more inspiration to effect improvements and more guidance in carrying them out than a meter on the boiler feed-water supply. The advantages of combining such a meter with its open heater was impressed upon the Harrison Safety Boiler Works, Philadelphia, and it has furnished a considerable number of its heaters so equipped.

The type of meter employed is the V-notch weir, in which the cross-section of the orifice occupied by the flowing water is always a triangle of the same shape having, therefore, a constant ratio of depth to width. At small flows the variations in head are rapid, giving a good percentage of accuracy. The formula connecting the head or depth in the weir with the quantity flowing was shown by Prof. James Thomson, of Glasgow University, in 1860 to be

$$F = 0.305\ H^{\frac{5}{2}}$$

where

F = Flow in cubic feet per minute;

H = Head in inches over apex of a 90-deg. notch.

A simple mechanism can be made to move the pen of a recorder in this relation to the depth of water in the weir as measured by a float, so that equal divisions upon the chart are passed over for equal increments of flow.

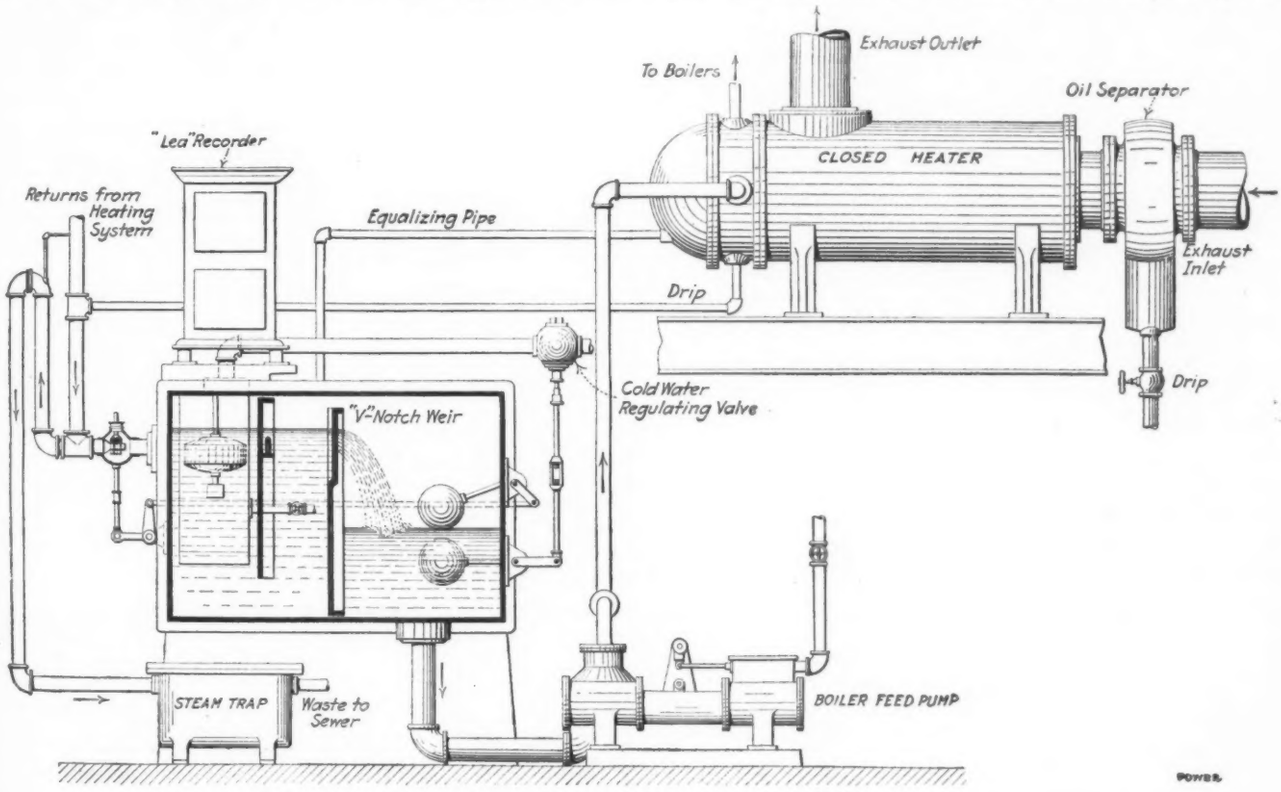


FIG. 1. COCHRANE FEED-WATER METER ARRANGED FOR USE WITH CLOSED HEATER

Such a meter requires but a small head for its operation, offers no inclosed passages nor constricted areas to be clogged up and provides storage between the measuring device and the pump so that the indications of the former are not affected by the vibrations set up by the latter. The placing of the meter in the heater makes it possible to measure water at any temperature or pressure.

In the Cochrane metering heater, or combined open feed-water heater and meter, the usual settling chamber is used as the still-water or approach chamber for the weir. A float in the outflow chamber on the down-stream side of the weir controls the cold-water valve through which make-up water is admitted to the heater and the open space above the water in the weir chamber is connected to the steam space of the heater by an equalizing pipe, as shown in Fig. 1. Where head room is limited

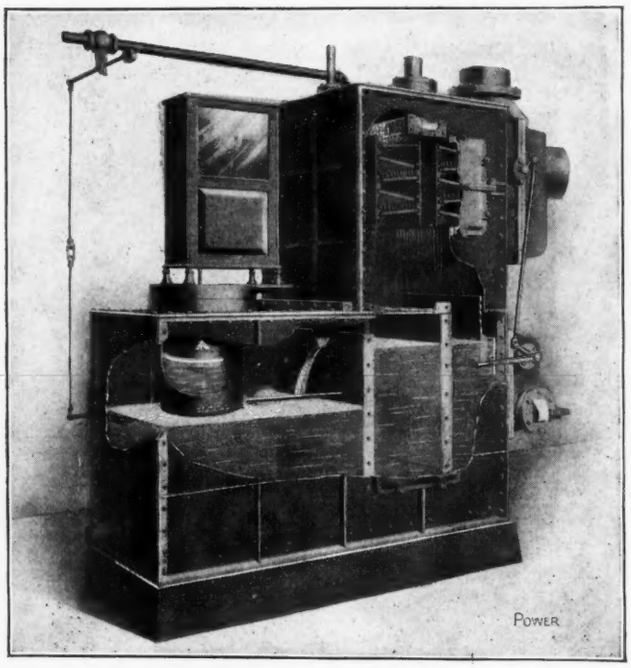


FIG. 2. BROKEN VIEW OF THE COCHRANE METERING HEATER

or large water-storage capacity is required a cylindrical form of heater is recommended. Where only part of the water is to be metered two-compartment heaters are supplied or a heater may be arranged to meter two supplies of water used separately. The metering apparatus can be attached to heaters already in use. Its connection to a closed heater is shown in Fig. 1, and to an open heater in Fig. 2.

The registering and recording mechanism is operated by a large copper float located in a chamber connected through a throttle or choke valve to the still-water chamber, and inclosed within the heater construction. From the float a brass rod rises vertically through a stuffing-box or anti-vapor gland into the recorder casing, where it carries a vertical rack engaging with a pinion mounted on the spindle of a spiral cam. This cam is so laid out that a pen carriage is caused to travel equal distances horizontally for equal increments in the rate of flow. The pen in turn bears upon a drum which is revolved once in 24 hr. by an eight-day clock. The chart upon which the record is made is wrapped around this drum, and, inasmuch as distances crosswise represent flow in pounds per hour, and distances lengthwise represent hours, the area of the chart under the pen tracing represents, to an appropriate scale, the total flow in pounds of water during any given period.

The area under the curve may be determined either by means of an ordinary planimeter, or an automatic integrating device can be provided which gives directly the total flow corresponding to any elapsed period. In any case the record made by the pen is of value independently of the integrated result, since it shows the variation from moment to moment throughout the day.

The vertical rack rod of the recorder is fitted with a pointer traveling over a scale divided into inches, which serves the double purpose of affording an easy means of initial adjustment of the instrument, and of computing the flow directly, independently of the cam. The surface of the cam is also marked so that the flow may be read off independently of the pen, furnishing a means for adjusting or checking the adjustment of the pen upon the chart at any time.

Two Cochrane metering heaters of very large capacity have recently been supplied for the new Two Hundred and First St. power plant of the New York Edison Co. The discharge of the condenser air pumps is first received in the metering hotwell located on the turbine-room floor, from which it divides and passes in equal parts to the two metering heaters on the floor below. This hotwell also receives and divides, but does not meter, the make-up water. It has a total capacity of 1,200,000 lb. of water per hour. The metering heaters are installed according to the double-unit system, that is, in parallel, both as regards the exhaust-steam supply and the withdrawal of water, each having capacity of 600,000 lb.

The meters are guaranteed to give a result when integrated over an hour, day or week, that will agree with the amount of water as determined by weighing, within 1½ per cent., variation in temperature of the water not to exceed 25 deg. F. above or below the temperature for which the instrument is designed.

In a test recently made at the works of the manufacturer upon a meter designed to deliver 300,000 lb. of water per hour an average error of only 0.48 per cent. was obtained.

❋

Thyssen Vacuum Pump

There has recently been put on the market an interesting centrifugal air pump for high-vacuum service. This pump is patented, is the design of Thyssen & Co., Mulheim-Ruhr, Germany, and has been in operation in many of the largest power stations of Europe for several years.

The development of the Thyssen air pump, herein described, was due to the necessity of having an efficient high-vacuum pump for large turbine units, that would take up little space and be free from the objections of reciprocating air pumps and at the same time eliminate the shortcomings of some of the centrifugal air pumps already on the market.

A section of the pump is shown in Fig. 1, from which will be seen that the machine is practically a double-impeller, single-stage centrifugal pump with horizontally divided case. Each impeller discharges into an annular nozzle from which the water emerges in a thin film of high velocity, entraining the air from the condenser

through an annular diffuser or conversion throat and discharging the mixture against atmospheric pressure.

The moving element consists of two single-stage impellers mounted right and left hand on a driving shaft and between them is mounted a disk carrying two nozzle rings. There are four of these nozzle rings, the other two being separate and stationary, one attached to the casing and the other forming a sliding sleeve which is controlled by a hand-operated external adjustment that can be moved axially, thus varying the width of opening between the rotating and stationary rings to regulate the quantity of water for a given speed and temperature of entraining water.

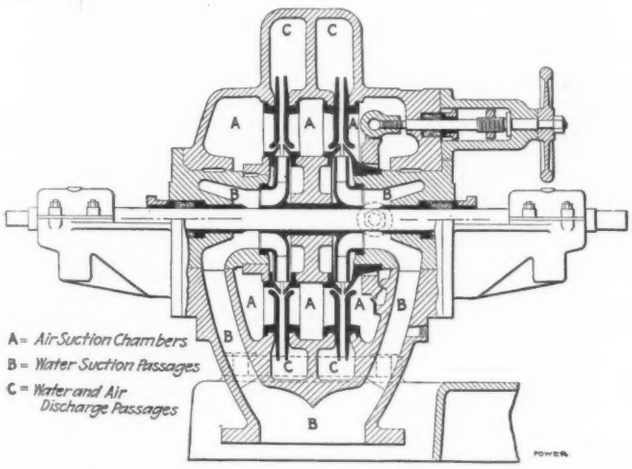


FIG. 1. CROSS-SECTION OF THYSSEN PUMP

The action of the pump is as follows: The entraining or "hurling" water is drawn into the pump, as in an ordinary centrifugal pump, and discharged by the impellers in two parallel films. Each discharge nozzle consists of a stationary and a revolving ring, by which the particles of water are given a swirling movement which greatly increases the air-entraining effect of the water leaving the nozzle rings. In order to permit the impellers to retain their central position under the nozzle rings with varying positions of the adjustable ring, a small lateral movement of the nozzle ring is immediately followed by a movement of the shaft endwise, bringing the pump instantly into hydraulic balance by discharging the water pumped by the two impellers through the annular openings of equal width between the two sets of nozzle rings. The pump is commonly located over a small tank, as shown in Fig. 3, but can be arranged to draw and discharge the entraining water in parallel with the circulating pump if preferred.

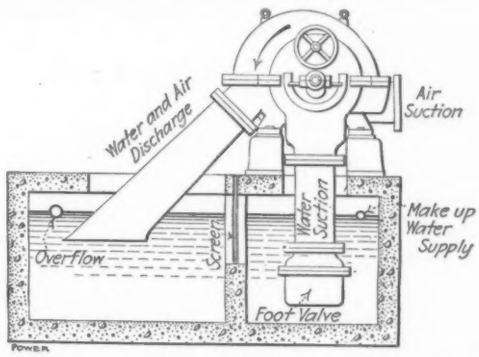


FIG. 3. THYSSEN PUMP AND CIRCULATING TANK

These pumps are built for a wide range of capacities; speeds from 1000 to 3000 r.p.m. being permissible, permitting either economical turbine drive or slower speeds to suit motors.

Many attractive pump combinations for surface, jet and barometric condensers are possible with this machine, as in Fig. 2, where the circulating, Thyssen air and centrifugal hotwell pumps for a surface condenser, taking care of a 3500-kw. steam turbine, are shown; the compactness and simplicity of the design being obvious.

The C. H. Wheeler Manufacturing Co., Philadelphia, Penn., has acquired the sole manufacturing and selling

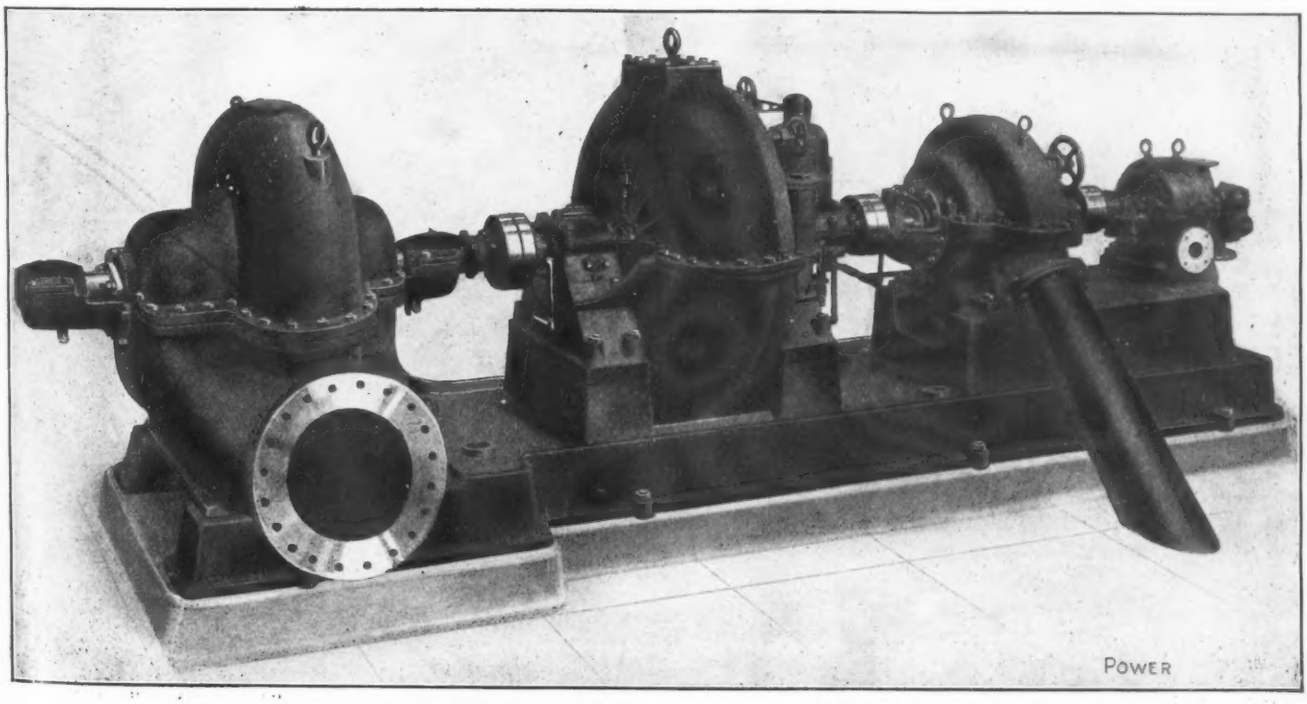


FIG. 2. TURBINE-DRIVEN AIR-CIRCULATING AND HOT-WELL PUMPS

rights for the Thyssen pump in the United States and Canada; and has already contracted to furnish a large number of them for various power plants. They are built in sizes up to 15,000 kw. capacity in one unit.

❋

The Abatement of Locomotive Smoke*

By D. F. Crawford†

Locomotive Combustion Rates

Dense smoke represents some wasted fuel and as the cost of fuel represents from 8 to 10 per cent. of the total operating cost of the railway, one of the most obvious ways of reducing operating expenses is to economize in the use of fuel.

To obtain from modern locomotives the average power required from them it is necessary to consume fuel at the rate of about 100 lb. of coal per sq.ft. of grate per hr., and to obtain the maximum power required it is necessary to consume 150 lb., and at times in excess of this amount, per square foot of grate per hour. That is, to obtain the power necessary to perform the work demanded, a boiler which from its heating surface would be rated at about 320 hp. is frequently forced to develop over 1500 boiler horsepower, and our records show that another boiler, which would on the basis of heating surface be rated at about 400 hp., has developed as high as 1994 boiler horsepower.

The performance stated above requires coal consumption at the rate of from 6000 to 10,000 lb. of coal per hr., and in the cases cited this was done on a grate of 55 sq.ft.

From the above it is surely evident that the abatement of the smoke from such combustion is beyond comparison with the simplicity of taking care of the smoke from a stationary boiler with the low rates of combustion obtained in such practice.

The Locomotive Stoker

For the past nine years the Pennsylvania Lines west of Pittsburgh have been working to develop a mechanical stoker for locomotive use, and the results so far have been sufficiently satisfactory to warrant its application to a total of 300 locomotives, of which 215 are at work—66 in passenger, 130 in freight and 19 in switching service.

Repeated comparisons of the smoke produced by locomotives with and without the stoker show that those equipped with the stoker may be operated with from one-tenth to one-third of the smoke made by similar locomotives in the same service without the stoker; the amount of the reduction depending on the class of service and continuity of the run.

Two locomotives, one with and one without the stoker, were attached to a double train of freight cars, so that each locomotive was loaded to its capacity, and observations of the smoke made while pulling the train up a heavy grade. In this case the average smoke was as follows:

Stoker-fired locomotive.....	8 per cent.
Hand-fired locomotive.....	78 per cent.

The superheater, which is now applied to many locomotives, and which will be applied to many more in the future, does much toward the abatement of locomotive smoke, in that it permits operation at a given power output with from 10 to 20 per cent. less coal than a locomotive developing the same power not provided with a superheater. Less coal being required, there will consequently be less smoke.

Perhaps the most difficult problem in the abatement of smoke from locomotives, is the reduction of the amount of smoke made at the locomotive terminals, where fresh fires are made, to prepare the locomotives for service.

Notwithstanding careful instructions, supervision and experiments with different fuels, mixtures of fuels, and appliances, a satisfactory solution has not yet appeared.

Several years ago endeavors were made to collect the smoke and gases by suction fans and pass them through water sprays to precipitate the heavier contents, but without success, the size, first cost and operation cost prohibiting a plant of sufficient capacity. A modification of this arrangement, in which the smoke and gases are forced through a considerable body of water, is about to be put in operation.

At the present time the Pennsylvania Lines has under construction, at the engine house in Allegheny, apparatus to carry the smoke and gases from the locomotives in which fires are being prepared, through an underground duct and a fan, discharging them into a stack 150 ft. high, 7 ft. in diameter. It is felt that this arrangement will not only carry the smoke and gases considerably above the buildings immediately adjacent to the engine house, but, owing to the size of the stack, permit of considerable precipitation of the heavier particles.

The stack will be so located that it will be possible to interpose smoke-washing apparatus between it and the fan, should a sufficiently promising method be developed.

Elimination of the Steam Locomotive

In the present state of the art, of course, this means the substitution of electric motive power for all the locomotives now in use, as no other method is now available.*

The performance of the locomotive boiler compares favorably with the average results obtained in stationary practice, and the performance of the complete locomotive of modern construction, is sufficiently efficient to permit obtaining a coal rate of 2.1 lb. per i.hp.-hr., or 2.5 lb. of coal per hp.-hr. delivered at the drawbar of the tender.

The cost of everything electric is enormous. The cost of the electric locomotive is at least double that of the steam locomotive, which it is supposed to replace, and before electric locomotives can be operated it is necessary to incur a large additional outlay for power houses, transmission systems, track preparation and all of the other apparatus and material which is necessary to complete an electric system.

One estimate brought to the attention of the writer, provides an investment of about $200,000 for each steam locomotive displaced, or about ten times the cost of each of the latter.

*Excerpts from a paper read before the 1913 convention of the International Society for the Prevention of Smoke.

†General superintendent, motive power, Pennsylvania Lines West of Pittsburgh.

*Except internal combustion. See "Power," Sept. 30, 1913, page 470, for description of the first Diesel locomotive.—Editor.

Staten Island Boiler Explosion

SYNOPSIS—Some light on the causes of the explosion at the plant of the Richmond Light & Railway Co., in which seven were killed and three badly injured.

In last week's issue brief mention was made of the disastrous boiler explosion which occurred at the plant of the Richmond Light & Railway Co., at Livingston, Staten Island, on Oct. 21; further details are herewith given.

As stated, six men were killed outright and four seriously injured; one of these has since died, making the total fatalities seven.

FIG. 1. VIEW FROM OUTSIDE OF BUILDING, SHOWING WINDOW BLOWN OUT

FIG. 2. LOOKING DOWN INTO BOILER ROOM THROUGH HOLE IN ROOF

The boiler was of the vertical Wickes type, rated at 300 hp. and had drums about 7 ft. in diameter. The pressure carried was 150 lb,; not 180 lb. as first reported. It had been installed in 1901 and the last internal inspection was made on Oct. 30, 1912.

As far as can be learned, the boiler had been washed out the day of the accident, and was put back in service to help carry the peak load. It had been cut in on the line only about 10 min. when the explosion took place.

The failure occurred in the bottom head, sending the boiler up through the roof like a rocket, the slight inclination causing it to descend in the Kill. The reaction drove the head with the mud drum attached, into the basement, these being found in the position shown in the sketch, Fig. 5. The mud drum was severed from the head, undoubtedly by striking a floor beam; this also caused the nozzle to be partly torn off through the rivets and the drum to be badly dented.

It will be remembered that the bottom head in this type of boiler is bumped to a radius equal to the diameter of the shell, but where the head is flanged up to join the drum it is necessary to depart from this radius. It was at this section (see Fig. 6) that the failure occurred in almost a perfect circle. Although there was some pitting of the lower head, it was not enough to cause apprehension and the metal at the line of the failure showed no signs of wasting away, in fact, it was little less than the original thickness of ¾ in.

In trying to account for the failure under these conditions it seems reasonable that with the "breathing" of the bottom head, the distortion would be greatest at the region of sharpest curvature, the very line along which failure occurred. This bending would tend to "fatigue" the metal and in this condition any sudden jar or impact might be sufficient to cause the rupture. It is not at all improbable that this initial force may have been caused by cutting in too quickly or by water-hammer. These are merely conjectures, however, and the coroner's inquest, which has not yet been held, may throw further light on what actually occurred when the boiler was cut in.

Previous to the explosion trouble had been experienced through failure of the braces which join the lower tube sheet with the bottom head; one of these showed evidence of having been welded. Although these braces are intended primarily to support the tube sheet it is possible that they may have indirectly affected the strength of the head.

The boiler is said to have received hard usage without

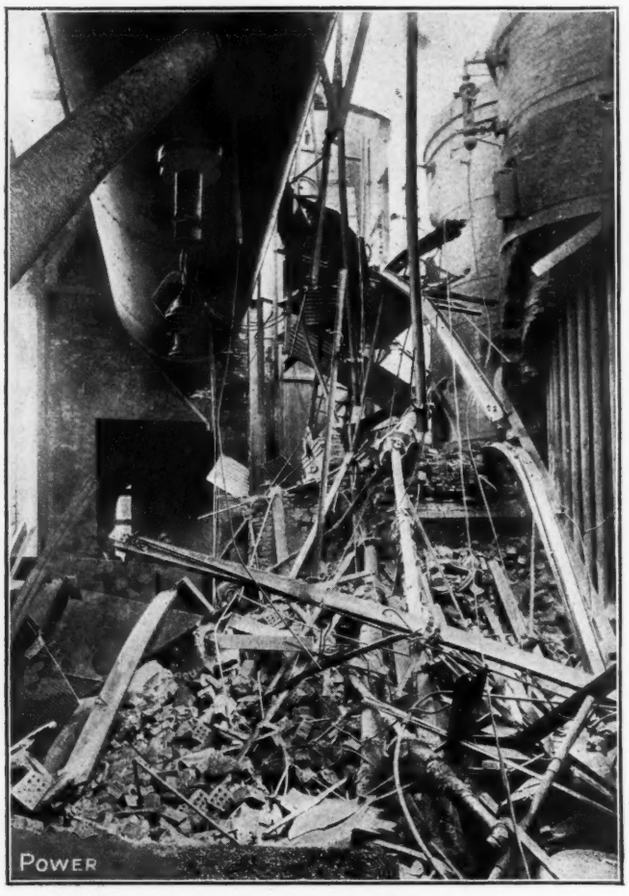


FIG. 3. DÉBRIS IN BOILER ROOM

proper attention, and about three years ago Wickes Bros., noting the conditions under which the boilers were being operated, and being apprehensive of the results, offered to buy back the three vertical boilers but were unsuccessful. Furthermore, owing to the general condition of the boiler plant and the attitude of the management, the consensus of opinion among insurance companies for some time prior to the accident was that it was a bad risk.

There has been considerable talk of raising the boiler

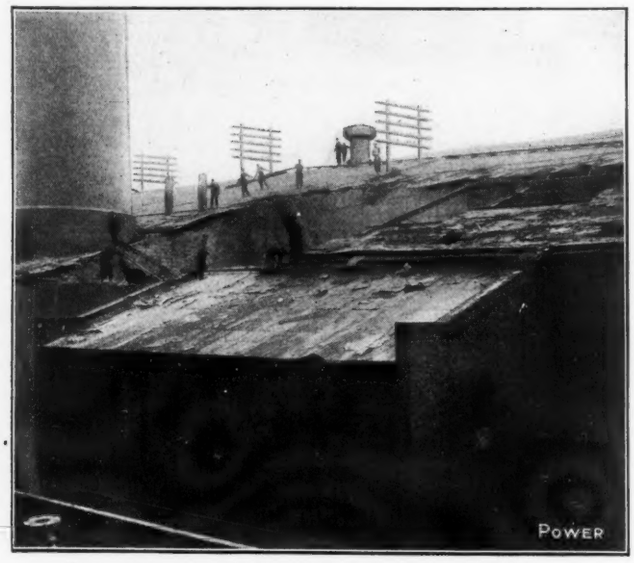


FIG. 4. SHOWING HOLE IN ROOF

from the Kill to permit further examination. It is improbable, however, that this would reveal much more than is already shown by the bottom head, as far as the actual failure is concerned, although it would show the general condition of the boiler and for this reason it is desirable.

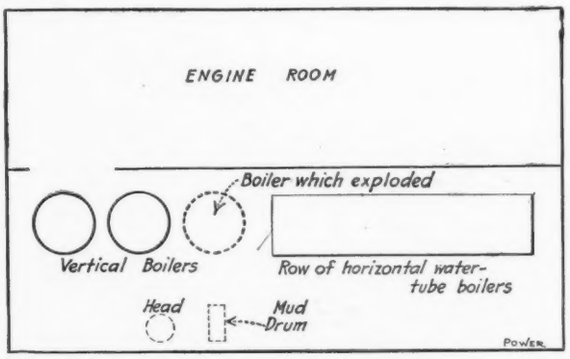


FIG. 5. PLAN OF BOILER ROOM AND POSITION OF HEAD AND MUD DRUM AFTER EXPLOSION

Staten Island was in total darkness for five nights as a result of the accident, although the engine room and the row of horizontal boilers were uninjured. The boiler which failed was situated between the stack and the other

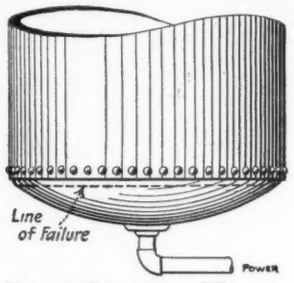


FIG. 6 SHOWING WHERE HEAD FAILED.

boilers; as a result a large section of the flue was demolished, and had to be replaced before service could be resumed.

Steam Turbines in a Modern Isolated Plant

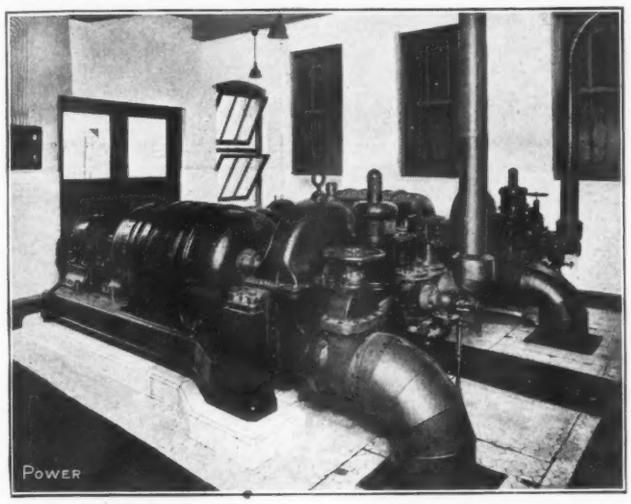
In electric-generating plants, the utilization of the exhaust from steam turbines for heating and in manufacturing processes often results in remarkable economy. The steam turbine is naturally the best suited to this condition, because of the steady supply of exhaust steam at a constant pressure and free from oil. Where this steam can be utilized, condensing operation is seldom justified.

The plant of the R. B. Davis Baking Powder Co., which is described herein, is a splendid example of this type of plant. The plant previously used live steam for drying and acid evaporation and purchased central-station current. They estimate a saving of 33⅓ per cent. over the old operating cost with their present equipment, including interest and depreciation, and it can readily be seen why the owners take pride and satisfaction in this plant.

The turbine room contains two Westinghouse alternating-current, turbo-generator units, of 150 kw. normal capacity each, having direct-connected exciters mounted up-

on the turbine bedplate. These machines generate current at 450 volts for lighting and power service about the works.

The turbines exhaust at practically atmospheric pressure and the supply of exhaust steam is used for heating and drying in the manufacture of baking powder. As the plant operates continuously night and day, there is a



TWO 150-KW. WESTINGHOUSE TURBINES WITH DIRECT-CONNECTED EXCITERS

continuous and practically constant demand for this exhaust steam. Live steam can be turned into the heating system in case of emergency. By means of an air pump the steam is withdrawn from the heating system under vacuum, and is fed back to the boilers through a Goubert water heater, a makeup supply of feed water being added. A feed temperature of approximately 200 deg. F. is obtained, the exhaust steam passing through the heaters on its way to the heating system.

In the turbine room there is a four-panel switchboard, peculiar in that the conductors are bare copper bars extending straight up from the switches and through a slate shelf above which they join the distribution leads. There are three transformers of 5 kw., each arranged in delta, the secondary not being connected in this case, as two of the plant buildings are supplied with three-wire, 220-110-volt current, and one building with two-wire, 110-volt current.

There is also a 15-hp. motor-generator set installed to carry the variable-speed, direct-current elevator load, consisting of two automatic A. B. C. elevators.

In the boiler room there are two 250-hp. Babcock & Wilcox boilers, the extra capacity being needed for furnishing live steam for evaporating acids in the baking-powder process. These boilers generate steam at 150 lb. pressure, using a good grade of Clearfield smokeless bituminous coal. With an electrical load factor of about 53½ per cent., including the steam used for acid evaporation, which is hard to estimate, the plant uses approximately 7½ tons of coal per day of 24 hr. There are installed about the plant about 225 hp. in motors of the squirrel-cage, induction-type, chosen for their advantages over the commutator type which are susceptible to trouble from dust.

Throughout the whole installation the most efficient use has been made of the power and the plant is a good example of sound engineering and commercial judgment.

❋

Huber Shaking and Dumping Grate

The illustrations shown herewith give an idea of the general design of the Huber shaking and dumping grate. The bars are made with two trusses running lengthwise with clips bridged across from truss to truss. These clips can be regulated for any size of opening desired. One truss is straight; the other is curved and deep, giving the bar extra strength to prevent warping, and a large opening when the bar is in a raised position.

Referring to Fig. 1, the grate-bar bearings are placed off the center line, which gives an eccentric movement toward the back of the furnace. This movement advances the coal to the rear of the furnace, sifts out the ashes and at the same time breaks up the fire. The grates are shown in their running position.

The stoking feature is shown in Fig. 2. Alternate grate bars are connected to a side bar, which is connected to a lever on the front of the furnace. On the other side of the grate is a similar side bar, connected to a second lever by which the remaining grates are operated. Pulling out on either lever brings the grates to the position shown which moves the fuel toward the rear of the furnace. When both levers are pulled the grates are in the position shown in Fig. 3. The bars can be raised from 1 to 5 in.

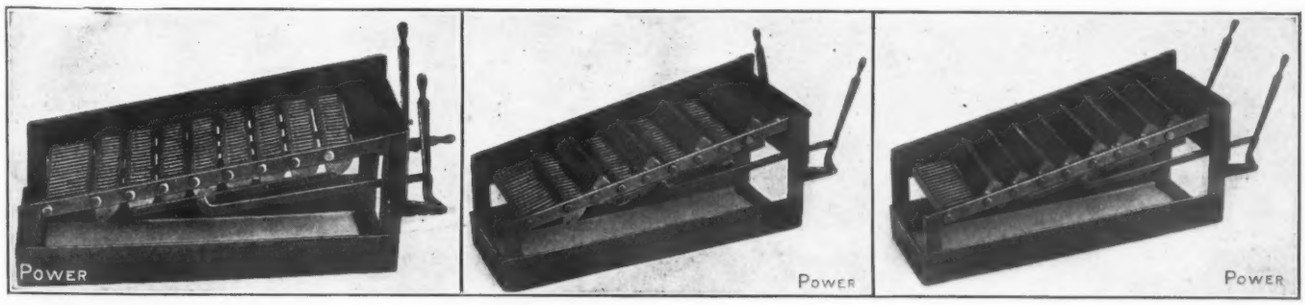


FIG. 1. FIG. 2. FIG. 3.

THE HUBER SHAKING AND DUMPING GRATE IN ITS VARIOUS POSITIONS

The grates are made with over 50 per cent. air space. The dumping grate is 12 in. wide. This grate is manufactured by the Huber Grate Bar & Stoking Co., 1114 East Monument St., Baltimore, Md.

❋

Two locomobiles of 350 hp. each have been imported from Germany by the Buckhorn Mining Co., of Nevada. They are to use crude oil as fuel, and were sold upon the guarantee of 0.6 lb. per b.hp.-hour.

Y. M. C. A. in Industrial Work

Nearly 3000 college engineering graduates and 3500 students from 160 colleges, reports the national association, are at work in the industrial field of the United States teaching foreign men and boys how to read and write, learn trades and become useful citizens. These teachers are members of the association, under its supervision, and call their work "the industrial-service movement."

For English-speaking workmen the plan includes instruction in shops and factories at the noon hour or after closing time; classes in mathematics, mechanics, drawing, plan-reading, etc.

The work is helping the engineer and student to acquire an intimate knowledge of shop conditions and become broad-gage executives, and is giving the workmen a better acquaintance with the college man, whom, as one employer expressed it, "we no longer think of as a snob."

❖

Panama's Exposition

The corner stone of the administration building to be erected on the site of the national exposition, which Panama proposes to hold in 1914-15 in commemoration of the four hundredth anniversary of the discovery of the Pacific Ocean by Vasco Nuñez de Balboa, was laid on Thursday, Sept. 25, by President Porras.

The sites allotted for the different buildings were blessed by the Bishop of Panama, Dr. William Rojas, and the plans were exhibited by Alejandro Bermudez, the director of the exposition. Following the laying of the corner stone, Dr. Ramón F. Acevedo, secretary of public works, made an address. The day was made a public holiday in Panama, partly on account of the corner stone ceremonies, and partly because Sept. 25, under the old calendar, was the date in 1513 when Balboa first saw the Pacific.

It is planned to open the exposition on Nov. 1, 1914, to continue six months, and for carrying out the project the Panama National Assembly has voted a preliminary credit of $150,000. The United States, Spain, and several of the neighboring Latin-American republics have been invited to participate. The grounds front the road to Las Sabanas, about opposite the orphan asylum, and cover an area of about 35 acres.—"Canal Record."

❖

International Engineering Congress

In connection with the Panama-Pacific International Exposition in San Francisco, in 1915, there will be an International Engineering Congress, in which engineers throughout the world will be invited to participate.

The congress is to be conducted under the auspices of these five national engineering societies, the American Society of Civil Engineers, the American Institute of Mining Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the Society of Naval Architects and Marine Engineers.

The organization and conduct of the congress are controlled by a committee of management consisting of the presidents and secretaries of these five societies, and of eighteen other members in or near San Francisco.

Col. George W. Goethals, chairman and chief engineer of the Isthmian Canal Commission, has consented to act as honorary president and is expected to preside in person over its general sessions.

The congress will hold its sessions during the week of Sept. 20-25, 1915, in the auditorium and section rooms which will be placed at its disposal by the management of the Panama-Pacific International Exposition Co.

Two important purposes are: First: The gathering together of a large and representative body of engineers from all civilized countries, with the opportunities which this will present of forming or renewing personal acquaintances, and of interchanging views on the various phases of professional work. Second: The reading and discussion of papers before the sections, and their later publication in such form as to constitute a valuable addition to any engineering library.

In scope of character, it is intended that the congress shall embrace, in a thorough and comprehensive manner, the various branches of the engineering profession. Eminent engineers throughout the world will be invited to contribute papers on assigned topics, and in selection and distribution the committee will use its best endeavors to render the series of resulting papers widely representative of the world's best engineering practice.

The general field of engineering to be covered has been divided into 10 groups which, together with the special field of the Panama Canal, will constitute 11 divisions, each presided over by a chairman eminent in the branches of engineering covered by his section. Each section will hold independent sessions, with such joint and general sessions as may be suitable. The following is a general indication of the sections and the branches of engineering which each will cover:

General Sessions: Official and general addresses, discussions on topics of general professional interest, business meetings, etc.: Section 1, the Panama canal; 2, waterways and irrigation; 3, railways; 4, municipal engineering; 5, materials of engineering construction; 6, mechanical engineering; 7, electrical engineering; 8, mining engineering; 9, naval architecture and marine engineering; 10, military engineering; 11, miscellaneous.

The official language will be English, and all proceedings and transactions will be so published. The papers solicited will be welcome at the choice of the author; if in other than English, they will be translated, and, together with all papers presented in English, will be printed in this language for presentation.

A special effort will be made to procure discussions, carefully prepared in advance, for presentation with the papers. In addition, there will be oral discussions at the sessions. It is anticipated that limitations of space may require the ultimate publication of all discussions in condensed or summary form. Written discussions will be welcomed in any language; if in other than English it will be translated for publication. It is expected that oral discussions will be limited to English.

The general fee for membership will be $5. This will entitle the member to receive the index volume and any single volume of the transactions he may select, together with the right of participation in all general activities and privileges.

It is expected that there will be arranged a number of excursions to points of engineering and general interest within practicable reach of San Francisco, and every effort will be made to enable visiting engineers to inspect personally such engineering works as are especially typical of engineering practice on the Pacific Coast.

Further information of general interest and importance will be given publicly through the technical press, and to all subscribers timely notice will be sent containing more complete and detailed information as to papers, sessions excursions, itineraries, etc.

PERSONALS

A. O. Krieger, at one time publicity manager of the Busch-Sulzer Bros.-Diesel Engine Co., St. Louis, Mo., has been placed in charge of the gasoline-engine sales department of the Whitman Agricultural Co., St. Louis.

Dr. Ira N. Hollis, president of the Worcester Polytechnic Institute and a vice-president of the American Society of Mechanical Engineers, was honored on Oct. 17 by a meeting and banquet in Worcester by the Massachusetts members of that society.

Francis MacLehose was recently appointed superintendent of the Chattanooga & Tennessee River Power Co.'s hydro-electric station at Hale's Bar, Guild, Tenn. This station is 33 miles below Chattanooga. Mr. MacLehose was graduated from the Stevens Institute of Technology in 1906, with the degree of mechanical engineer, and was in the operating department of the New York Edison Co. for seven years following his graduation.

President C. O. Mailloux, of the American Institute of Electrical Engineers, who is soon expected home from a European trip, where he attended the meetings of the International Illumination Commission in Berlin last August, and the International Electrotechnical Commission in September, has been signally honored by the President of France, who has conferred upon him the decoration of Chevalier of the Legion of Honor.

❖

Bulletin No. 17 on "The Manufacture and Use of Shelby Seamless Steel Tubing," which has recently been issued by the National Tube Co., of Pittsburgh, contains in its 39 pages some very interesting and valuable information on the above subjects. The bulletin is made up from extracts from an address by J. H. Nicholson and Emil Holinger to the U. S. Naval School of Marine Engineering. It discusses the processes of manufacture, materials for steel pipes, the making of specifications and the application of tubular sections to machine design. The information imparted is not generally found elsewhere so that the bulletin should be of general interest. A copy will be sent by the company upon request.